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Higher Corn Prices: Income or Expense?

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AGRICULTURAL ECONOMICS RESEARCH

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Best Article Award

"Model Validation and the Net Trade Model" by William E. Kost of the International Economics Division, ESS, was selected as the best article in *Agricultural Economics Research* during the publication year ending April 1980. The article, which appeared in Vol. 32, No. 2, April 1980, summarizes and illustrates methods of evaluating the goodness of fit of a model and methods of comparing model forecasts with forecasts from other sources. Each year *Agricultural Economics Research* will recognize the outstanding contribution to technical research in agricultural economics or statistics appearing in this journal.

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In This Issue

One of the great myths about scientific method is that knowledge is objectively determined and that the personal element is not of consequence. Michael Polanyi helped expose this myth. He showed that complete objectivity is not only a delusion but also a false ideal. The articles in this issue illustrate how important personal knowledge and judgment are in determining what problems we work on, what theories we use to explain them, and what interpretation we place on the empirical results of our research.

Agricultural prices are usually described with Laspeyres indexes which use base-period quantities as weights. Schluter and Lee have a different idea about how to describe agricultural prices. They examine the consequences for value added of changing prices for the various industries in an input/output model while holding quantities of goods and services fixed at base-period levels. The results are analogous to a Laspeyres price index in that both procedures use base-period quantities as weights. The interindustry linkages in the Schluter-Lee formulation provide for consistent disaggregation of the index by industry. The linkages also provide appropriate allowances for prices paid as well as received. For example, higher corn prices increase the income of corn growers, but increase the expenses of cattle feeders. The Schluter - Lee index indicates a reduction in net income to producers of meat animal products during the midseventies as a consequence of higher prices paid for feed grains and hay—a result which is not obvious from the usual index of prices received and paid by farmers.

Researchers are sometimes lulled into a false sense of security when they find the R^2 and t statistics in a regression analysis to be large. Bishop warns that such statistics frequently are misused by agricultural economists. They often overlook the warnings provided by other statistics, such as the Durbin-Watson, which indicates the presence of autocorrelation. Bishop illustrates some things a researcher can do to protect against the misuse of summary statistics in regression analysis.

The role of advertising in determining prices and quantities, measuring economic efficiency, and evaluating social welfare is sometimes neglected, according to the article by Connor. He reviews the literature of advertising, which persuades and informs, and which develops an image that differentiates one product from another. Connor recommends that researchers do more to recognize the economic role of advertising in models of agricultural marketing and prices.

The data usually considered ideal for a thorough evaluation of a program generally are not available. Researchers, therefore, have to use some ingenuity to make do with what they have. Lamm uses regression analysis to evaluate the impact of the voluntary anti-inflation program for retail food prices. His innovative technique is to introduce dummy variables into a set of commodity regression equations to indicate those for which the program was in place. Commodities for which the dummy's coefficient is significantly negative are presumed to have successfully met the program's goal of price reduction. Lamm finds the impact of the anti-inflation program was most significant for cereal and bakery products, sugar and sweets, other prepared foods, and processed fruits and vegetables.

Clark Edwards

Contents

Effects of Relative Price Changes on U.S. Food Sectors, 1967-78

By Gerald Schluter and Gene K. Lee*

Abstract

For a half-century the parity ratio has served as the most commonly used measure of the effects of relative price changes on the farm economy. The authors present a consistent economic model which measures the price-related income effects of relative price changes in selected sectors of the U.S. economy during the 1967-78 period and use this model to analyse selected sectors within the food system. Their model improves and expands upon the parity ratio. It provides more detailed information within the farm sector, and it provides conceptually consistent measures of the effects of relative price changes in the nonfarm sectors of the food system.

Keywords

Relative price changes, Parity ratio, Input-output analysis, Food system, Farm sector, Inflation

The first step, forming a clear idea of the ultimate use of the result, is most important, since it affords the clue to guide the compiler through the labyrinth of subsequent choices. It is, however, the step most frequently omitted.

Wesley Mitchell, 1915

Introduction

Mr. Mitchell was referring to constructing a price index, but his advice is as true today as it was 65 years ago (*5*).[1] Equally true, we suggest, is a corollary for choosing a price series. The first step, determining the purpose for which the price index is constructed, is most important, since it affords the clue to guide the user through the labyrinth of subsequent inappropriate uses. A classic example of the failure to follow this corollary is the parity ratio.

The parity ratio has survived 50 years of criticism, and it will likely continue to be used because it is timely (some price data are only about 2 weeks old when published), readily available, and easily understood. In this article, we briefly review its suitability as an indicator of the effect of relative price changes on agriculture and compare it with two alternative price series. Then we present a consistent economic model which measures the effects of relative price changes on selected farm, food-processing, and energy-related sectors of the U.S. economy during the 1967-78 period, which, we propose, provides a better indicator of the effects of relative price changes in the food and agricultural sectors.

At the core of most attempts to support farm income has been the desire to maintain the purchasing power of farmers. Often this effort has taken the route of maintaining relative prices, since makers of agricultural policies have recognized that high or low prices for farm products are not in themselves of major importance. Of far greater importance is the purchasing power of farm products in terms of the items farmers must buy for living and for their businesses. In response to these needs, the U.S. Department of Agriculture (USDA) developed, and first published in 1928, the parity index. The parity index, or the Index of Prices Paid by Farmers for Commodities and Services, Interest, Taxes, and Wage Rates, is expressed on the 1910-14 = 100 base. This parity index was used in conjunction with the Index of Prices Received by Farmers to yield a measure of farmers' purchasing power. One obtains this measure, the parity ratio, by dividing the Index of Prices Received by the parity index. The concept of a parity ratio has been critized almost from its start (*3*). Many criticisms have resulted from improper use by data users rather than from problems with the parity ratio series itself. The parity ratio is a price comparison. It is not a measure of cost of production, standard of living, or income parity (*9*). Nor is it more than one of many indicators of well-being in the farm sector. Many of the criticisms of the parity ratio have resulted from attempts—contrary to Mitchell's advice—to make it serve roles for which it was never intended.

Because the Prices Received Index reflects only farm commodities and the parity index includes farm-household consumption items as well as production expenditures, the

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[1] Italicized numbers in parentheses refer to items in the references at the end of this article.

parity ratio most closely mirrors the situation of a farm-operator household in which the household's income comes entirely from farm production. Relatively few farm households today depend solely, or even primarily, on income from farm sources. Moreover, using the ratio as a broader indicator to measure relative price changes for agriculture as an economic sector presents some conceptual problems. The Prices Paid Index is more inclusive than the Prices Received Index. In addition to current production items, the parity index includes consumption items and capital expenditure items, as well as inflation premiums in interest rates and possibly in capital inputs. Heady (*1*, p. 142) points out the parity ratio is faulty in a formal supply sense because the parity index does not include the implicit cost of resources already committed and specialized to agriculture. A sector measure of relative price changes would include only the prices of current output and current inputs. Considering only current output and input prices has the additional advantage of avoiding the measurement problems which Heady enumerates and the problems of quality adjustment in capital goods prices and inflation premiums in interest rates.

A price series which meets this criterion, measuring only current economic activity in the farm sector, is the implicit price deflator for gross national product (GNP) originating in agriculture, or the gross farm product (GFP). The implicit GFP deflator includes on the output side not only prices of commodities sold but also changes in farm-related income, the value of inventory changes, and selected imputed items, and on the input side, purchased current goods and services and rents paid. Comparing the implicit GFP deflator to the implicit GNP deflator provides a reference as to how price changes affect the farm sector relative to the general economy. Applying this approach, we present a consistent economic model[2] in which the combined price effects on 16 farm commodity sectors nearly add to the implicit GFP deflator and in which the price effects on all the model's sectors nearly add to the implicit GNP deflator.

Figure 1 presents three alternative measures of the effects of relative price changes on the farm sector. The "parity ratio" line (PR/PI) presents the traditional—albeit inappropriate for our purpose—measure of the farm-sector relative price.

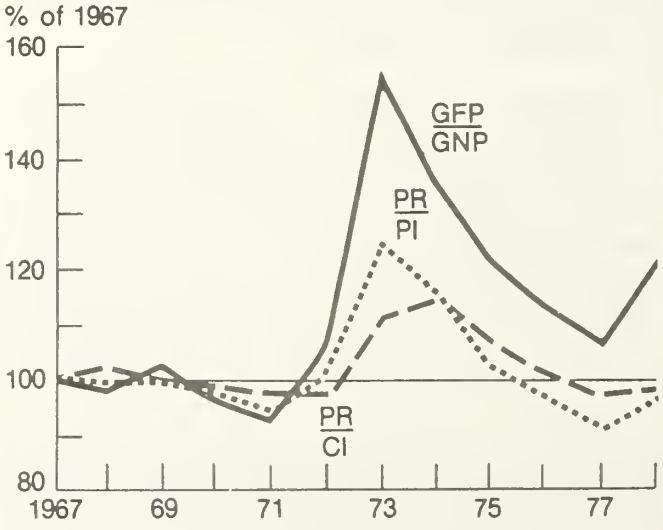
[2] In a consistent economic model the output of each industry is consistent with the demands, both final and from other industries, for its products. A consistent economic model insures that estimates for individual sectors and industries will add up to a total estimate (for example, GNP).

Technically, the parity ratio is defined on a 1910-14 base; however, we use the same price series with a 1967 base. The GFP/GNP line is the standard just discussed and also illustrates the type of standard used in applying the model. The PR/CI line presents an unpublished price series constructed to make the parity ratio approach a more appropriate concept for our purposes. As in the "parity ratio" line, the numerator of the ratio is the Prices Received Index (1967 = 100). The denominator, however, is the Index of Prices Paid by Farmers for Production Items after removing capital items (autos, trucks, tractors, machinery, and building and fencing materials). The remaining index and resulting ratio reflect current production activity.

The three measures follow similar patterns. All three measures agree that for 1970 and 1971 farm purchasing power decreased and that for 1973-75 farm purchasing power increased. The average of the ratios for 1967-78 for all three measures exceeds 100, suggesting that even though the two "parity ratio" related measures ended the period below 100, farm purchasing power increased relative to the general economy over the entire period.

Figure 1

Alternative Price Series Measuring Relative Price Effects on Farming



Many of the criticisms of the parity ratio have resulted from attempts—contrary to Mitchell's advice—to make it serve roles for which it was never intended.

Purchasing power as reflected here is purchasing power due to relative price changes but not to any change in the volume of economic activity. Our measure of farm-sector purchasing power (implicit GFP deflator) is also conceptually consistent with the general measure of the dollar purchasing power in the general economy (the implicit GNP deflator). Here we present a consistent economic model which provides similar estimates of the effects of relative price changes during the 1967-78 period on selected farm, food-processing, and energy-related sectors of the U.S. economy. We demonstrate that our individual farm sector estimates nearly add to the GFP implicit price deflator and together with nonfarm sectors nearly add to the implicit GNP deflator.

Method

The economic model used for our analysis is adapted from Lee and Schluter (*4*). We used an input-output framework to measure the income effects of a change in relative prices on each sector of the model.[3] Outputs in the model are held constant; so are the values for imports and the inter-industry flows. The constants function as weights for price changes in the same way that base-period quantities function as weights in a Laspeyres price index, such as the parity index. This similarity to a Laspeyres price index provides a check on the model's performance and shows the vulnerability of the food sector to the relative price changes which have accompanied recent inflation. We used a simplified form of the Lee-Schluter model:

$$r = [e\, D_p(I\text{-}A) - m]\, D_0$$

where:

- r = $1 \times n$ vector of values added, v_i
- e = $1 \times n$ vector of 1's
- D_p = $n \times n$ diagonal matrix of price changes relative to a year; p_{it}/p_{i0}
- I = $n \times n$ identity matrix
- A = $n \times n$ technical coefficients matrix, a_{ij}
- m = $1 \times n$ vector of import coefficients, m_i
- D_0 = $n \times n$ diagonal matrix of base period sector output, O_i.[4]

Thus, the value-added series for a particular industry is the 1967 value added to cover profits, rents, interest, taxes, and wages adjusted for changes in that industry's output price and its intermediate input prices. Import prices are held constant at base-period levels.

For our analysis, we used a 42-sector aggregated version of the 1967 national I/O table (*13*) for the import and the domestic input-output coefficients and, thus, for the base-year income, final demand, and output estimates. Table 1 presents these 42 sectors with the price series selected to represent the annual changes in price level of each sector.

Evaluation

Table 2 summarizes the model's performance. Column 1 gives the model's estimate of the implicit price deflator for farm value added; column 2 gives the U.S. Department of Commerce implicit price deflator for GFP; and column 3 gives the ratio of the two series. As column 3 shows, except for 1974, 1977, and 1978, all the model's estimation errors were 2.8 percent or less. An analysis of the pattern of estimation errors suggests a subtle difference in weights between those implicit in the I/O matrix and those implicit in the price series used by Commerce. The I/O model apparently assigns more weight to the crop sectors. Thus, when livestock prices increase relative to crop prices, our model underestimates the Commerce series. As many crop prices were rising in 1974 while many livestock prices were falling, our model overestimated the implicit price deflator for that year.

Columns 4 through 6 compare total GNP for the 1968-78 period.[5] Our model estimated better for the whole economy than for an individual sector (farm, in this case), with an average error of 1.1 percent and with only one estimation error above 2.5 percent. The model consistently underestimated GNP during the period from 1967 to 1975.

[3] The definition of income in input-output is synonymous with the value created. Thus, residual income includes proprietors' income, rental income, corporate profits, net interest, business transfer payments, indirect business taxes, and capital consumption allowances.

[4] Conventional I/O notation uses X to refer to the value of output. We use P_iO to distinguish between the value of output (X_i or P_iO_i) and real output (O_i).

[5] A comparison of columns 2 and 5 shows another difficulty in determining the role of agriculture in general inflation. The volatility of agricultural prices leads to volatile estimates of their role in general inflation. The 1978 implicit GFP deflator of 232.6 represents an 8-percent annual rate of increase, well above the 6.1-percent rate in the GNP deflator. Yet the GFP deflator decreased in 5 of the 11 years; almost all the increase came in 1969, 1972, 1973, and 1978. Thus, while the GNP deflator increased each year, in only 4 of the 11 years, did the change in the GFP deflator rate exceed the change in the GNP deflator-rate. Over the 11-year period, the farm-sector price deflator grew faster than the national deflator rate. Yet, in 6 of those 11 years, the rate of increase in the farm sector was less than one-third that for general price levels.

Table 1—Sectoring plan and associated price series[1]

Sector number	Sector description	Price series[2]
1	Dairy farm products	Farm income accounts, season average
2	Poultry and eggs	do.
3	Meat animals	do.
4	Miscellaneous livestock	do.
5	Cotton	do.
6	Food grains	do.
7	Feed grains	do.
8	Grass seed	do.
9	Tobacco	do.
10	Fruits	Prices received
11	Tree nuts	Farm income accounts, season average
12	Vegetables	Prices received
13	Sugar crops	Farm income accounts, season average
14	Miscellaneous crops	do.
15	Oil-bearing crops	do.
16	Farm-grown forest and nursery products	Prices received
17	Meat products	Producers Price Index
18	Dairy plants	do.
19	Canning, freezing, and dehydrating	do.
20	Feed and flour milling	do.
21	Sugar	do.
22	Fats and oils mills	do.
23	Confectioners and bakeries	do.
24	Beverages and flavorings	do.
25	Fertilizers	do.
26	Petroleum refining and related products	do.
27	Miscellaneous food processing	do.
28	Tobacco manufacturing	do.
29	Textiles, apparel, and fabrics	do.
30	Leather and leather products	do.
31	Crude petroleum	do.
32	Coal mining	do.
33	Forestry, fishing, and other mining	do.
34	Other manufacturing	do.
35	Transportation and warehousing	WEFA
36	Wholesale and retail trade	do.
37	Other noncommodities	do.
38	Electric utilities	Producers Price Index
39	Gas	do.
40	Real estate	WEFA
41	Special industries	Assumed unity
42	Imports	WEFA

[1] Detail greater than was required for the food-system analysis, reflected in the sectoring plan, is due to the inclusion of alternative-sector, analytical capabilities for the model.

[2] Farm income accounts = season average price used in cash receipt estimates; Prices received = Index of Prices Received by Farmers; Producers Price Index = U.S. Bureau of Labor Statistics' Producers Price Index; WEFA = (*15*). The specific variables from these series for each sector are available from the senior author upon request.

Columns 7 through 9 provide a third measure of the performance of our model. Column 8 gives the actual ratio of the GFP deflator over the GNP deflator as graphed in figure 1. Column 7 gives the ratio of our estimates of these statistics, and column 9 gives the ratio of our estimates of the ratio to the actual ratio. Our model predicted the actual ratio within 2 percent for 7 of the 11 years. Although fairly sizable errors occur in 1973, 1974, 1977, and 1978, only in 1977 does the model incorrectly predict the movement of the GFP deflator relative to the GNP deflator.

These implicit value-added price series are useful economic data not otherwise available. They show the analysts how the sector has fared in the maze of interacting price relationships that characterize a dynamic economy.

The relative movements provide useful information. One must avoid giving too much weight to the levels as the level of output and input substitution have been fixed at base-year levels. Thus, the income level estimated by the model may differ from the actual income level of the sectors. A

These implicit value-added price series are useful economic data not otherwise available. They show the analysts how the sector has fared in the maze of interacting private relationships that characterize a dynamic economy.

Table 2—Comparison of model estimates with gross farm product (GFP) and gross national product (GNP) deflators, 1968-78

Year	GFP deflator			GNP deflator			GFP deflator/GNP deflator		
	Estimate	Actual[1]	Estimate/ actual	Estimate	Actual[1]	Estimate/ actual	Estimate	Actual	Estimate/ actual
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1968	103.4	102.8	1.006	103.9	104.5	0.994	0.9952	0.9837	1.0117
1969	109.5	112.4	.974	109.0	109.7	.994	1.0046	1.0246	.9805
1970	109.3	111.4	.981	113.4	115.6	.981	.9638	.9637	1.0001
1971	109.7	112.7	.973	118.6	121.5	.976	.9250	.9276	.9972
1972	131.1	133.7	.981	122.5	126.6	.968	1.0702	1.0561	1.0134
1973	212.2	207.1	1.025	130.6	133.9	.975	1.6248	1.5467	1.0505
1974	218.9	199.5	1.097	145.9	146.8	.994	1.5003	1.3590	1.1040
1975	193.5	195.2	.991	160.8	160.9	.999	1.2034	1.2132	.9919
1976	192.4	191.6	1.004	169.5	169.2	1.002	1.1351	1.1324	1.0024
1977	179.0	191.4	.935	180.3	179.3	1.006	.9928	1.0675	.9300
1978	221.1	232.6	.951	193.8	192.4	1.007	1.1409	1.2089	.9437

[1]Source: (*14*).

final caveat: it is difficult to establish a base year when all sectors of the economy were "normal," and determining the base year by the scheduling of an economic census may increase the likelihood of choosing a year when a number of sectors were atypical. In our model, these atypical situations have become the norm by which other years are measured. One must remember this difficulty when making intersectoral comparisons.

Relative estimates of the effect of price changes are derived from an economic model which describes the interrelatedness of the U.S. economy. The model is consistent. The model can be validated, and we did validate it, by aggregating individual sector estimates for comparison with published aggregates. However, this is not the chief value of our method. More important, this series is the first systematic, internally consistent set of estimates of the relative vulnerability of parts of the food system to recent relative price changes. These estimates for individual sectors include the price-related income effects on all participants, farm operators, workers, interest recipients, and others who commit factors (labor, capital, land, and others) to the individual sectors.

Model Limitations

The model uses the level and mix of real output in 1967. Thus, the model does not incorporate any changes in income earned by a sector due to changes in level of output or the mix of final demand. It only accounts for changes in income due to changes in relative prices.

Similarly, the weight given each price in calculating this income effect is its weight in the 1967 industry cost function (direct requirements column). Thus, input substitutions due to price changes are ignored, as are input coefficient changes due to changes in production technique. Although these assumptions could lead to potentially serious biases, this problem is common to the use of fixed-weight indexes. Although we do not overlook this potential bias in our model, we accept it as an occupational hazard. Due to the fixed weights, the results can be interpreted as the change in the value added, with all input (primary and intermediate) and output quantities held fixed because of price changes occurring during the 1967-78 period.

Another potential source of error in the model occurs when the series chosen to represent the price effects of a specific sector fails to fulfill this function. The price series chosen may not properly reflect the price changes in that sector, or the collection of price data may differ from commodity marketing patterns.

Finally, these income estimates should not be confused with sector or industry profits, although profits are a component of the income estimates. Rather, our income estimates include wages, interest, depreciation allowances, rents, and indirect business taxes as well as profit-type income. Thus, one dollar of increase in income represents one more dollar of income available for distribution to these factor suppliers.

Results

We discuss our results by groups of sectors. The crop sectors are divided into those more directly influenced by world markets and those more reliant on domestic markets. The food processing sectors are divided into those processing farm livestock products, those processing farm crop products, and those further processing food products. Groups also discussed are farm livestock and energy-related sectors.

Figures 2 through 6 depict graphically our results as percentage variations from the income level in 1967. Thus, a value of zero represents no change; a value of one represents a doubling of base-year income; and a negative number represents an income loss. The implicit GNP deflator is included in each figure to provide a comparison with the overall rate of inflation.

World Market Crop Sectors

Figure 2 presents the estimated income levels of the export-oriented crop sectors relative to the 1967 levels. During the 1968-70 period, relative prices moved to the economic detriment of all these sectors, and their incomes fell below 1967 levels. The oil crops sector first crossed the baseline in 1971 and was 33 percent above it by 1972. Then, with the export boom, the domestic terms of trade shifted dramatically in favor of all four of these crop sectors. The most dramatic shift occurred in the food-grain sector. All four sectors peaked in 1974; income levels fell in 1975 and continued to fall in 1976, except for cotton (for which price and income recovered to above 1974 levels) and for oil crops (which rose slightly from its 1975 income level). In 1977, the oil crops sector continued to rise, but the others dropped. Cotton and food grains rose in 1978; but oil crops stabilized, and feed crops continued to fall.

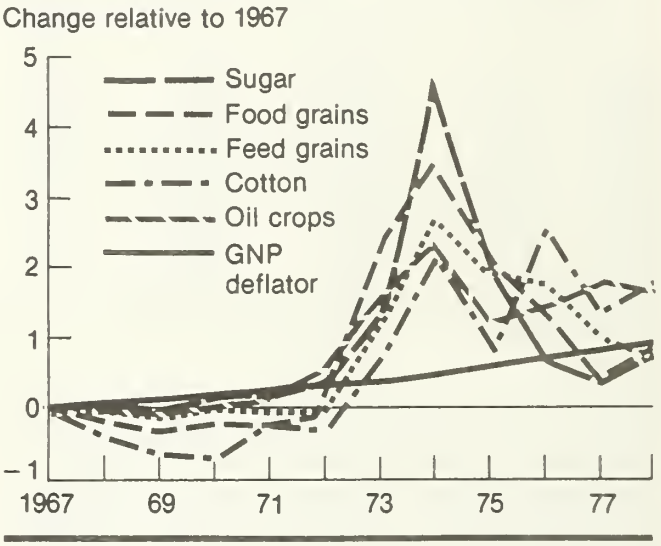
Because we import a significant share of our domestic sugar, the sugar crop sector is subject to different forces than are other crops. With the expiration of the Sugar Act and a strong world demand for sugar, the income of the sector soared in 1974, dropped (but remained strong) in 1975, and fell again to near 1967-73 trend-line levels in 1976, 1977, and 1978 (fig. 2).

Domestic Crops

In contrast to the world-market crop sectors, the income of the domestic crop sectors (vegetables, fruits, and tree nuts) did not shift dramatically due to relative price movements.

Figure 2

Change in Income Due to Price Changes, World Market Crop Sectors



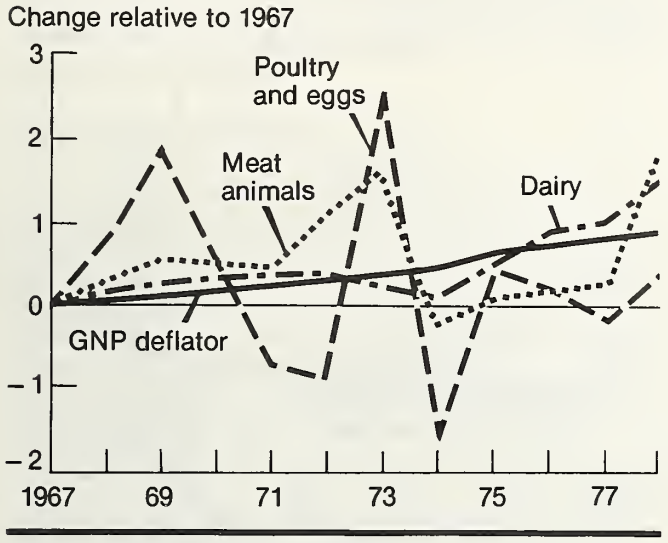
In fact, except for 1968 and 1973, the value-added indexes of these sectors were consistently below the overall standard (the GNP deflator) until 1978, when fruits and tree nuts finished the 1967-78 period above the standard.

Livestock Sectors

The livestock sectors, especially poultry and eggs, were more vulnerable to price changes (fig. 3). Some of the variability in poultry and egg income was due to a relatively low income level in the base year, which accentuated the degree of income fluctuations as relative prices changed. Furthermore, the output price for this sector tends to vary more than the input prices, which introduces income variability. Thus, in 1968 and 1969, poultry and egg prices were 7 and 21 percent, respectively, above 1967 levels, leading to income 80 and 180 percent, respectively, above the base period. Conversely, in 1971 and 1972, when price levels were only 3 and 5 percent, respectively, above 1967, income levels were 73 and 89, percent, respectively, below 1967. A subsequent price rise in 1973, to 79 percent above 1967 levels, sent incomes soaring, to 250 percent above base level. When the

Figure 3

Change in Income Due to Price Changes, Livestock Sectors



poultry and egg price index dropped 17 index points in 1974, while the feed crop price index increased 72 index points and the grain mills (manufactured feeds) PPI increased 22 index points, the poultry and egg sector income plunged to negative levels. Subsequent strength in poultry and egg prices, together with weaker feed prices, allowed 1975 and 1976 estimated income levels to recover to levels 38 and 15 percent, respectively, above base period before falling again below base level in 1977 and recovering to 28 percent above base level in 1978.

The meat animal sector was less volatile than the poultry and egg sector because of a larger base-year income and more stable output prices. The sharp drop in the meat animal index in 1974 does not appear in other economic indicators, such as the Index of Prices Received by Farmers for Meat Animals. Figure 4 dramatically illustrates the superiority of the proposed index of relative income over ordinary price indexes. The relative income index allows explicitly for higher feed costs, whereas the Index of Prices Received by Farmers for Meat Animals does not. The meat animal sector experienced 2 strong years (1972-73) before price weaknesses and higher feed costs took their toll. From 1974 to 1977, the Index of Prices Received by Farmers for Meat Animals was fairly constant (165, 169, 170, and 168); thus, any increase in strength of sector income resulted from slightly lower input prices. Price strength in 1978 improved the income position of this sector to 175 percent above base level. Relying solely on the Index of Prices Received by Farmers for Meat Animals would have been misleading because of changes in input prices.

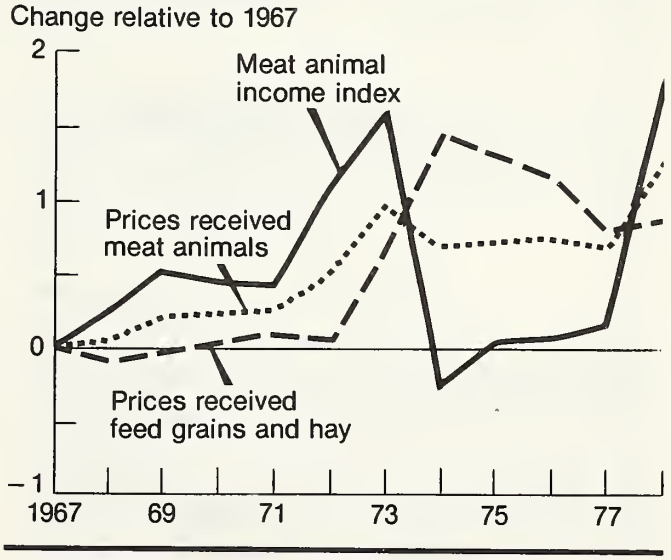
The income pattern in the dairy sector (fig. 3) was rather stable for most of this period, with exceptional strength since 1976. From 1975 to 1978, the dairy-product price index rose 20 percent above 1975 levels, whereas the feed-crop price index fell 20 percent. As a result, sector income rose from 39 percent above base level in 1975 to 143 percent above base level in 1978.

Livestock Processing

The stable price and income pattern that we observed for the farm dairy sector is even more pronounced for the manufactured dairy products sector (fig. 5). From 1967 through 1975, the estimated income levels stayed within 10 percent

Figure 4

A Relative Income Index Contrasted With Comparable Price Indexes



of base year levels; not until 1976 did they exceed 10 percent. Nonetheless, the sector was losing ground relative to the implicit GNP price deflator. Apparently, this sector is able to pass on increases in the farm price of milk, but the demand for milk prevents larger increases.

The meat- and poultry-processing sector faces a different demand situation (fig. 5). As the farm price of meat animals and poultry rose in 1971-73, the meat- and poultry-processing sector apparently did not pass on higher raw product costs, and income levels fell almost 40 percent below base level. After 1973, the PPI for processed meats showed more resilience than farm prices, and the income position of this sector rose during the 1974-75 period; it later dropped to more modest levels.

Farm Crop Processing

Figure 6 shows the variety of income responses of food manufacturing sectors to explicit changes in prices of their respective farm raw materials. The feed and flour-milling sector exhibits tendencies similar to those in the meat-processing sector. Millers apparently did not pass on all costs of higher priced grain inputs during 1974 and 1975, and incomes dropped to near 1967 levels. But their 1976 and 1977 output prices rose 4 and 2 index points, respectively, over 1975 levels, while the food-grains price index fell 37 and 80 index points, respectively, from 1975 levels, resulting in income jumps of 43 and 54 percent, respectively, above base levels.

Figure 5

Changes in Income Due to Price Changes, Livestock Product Processing

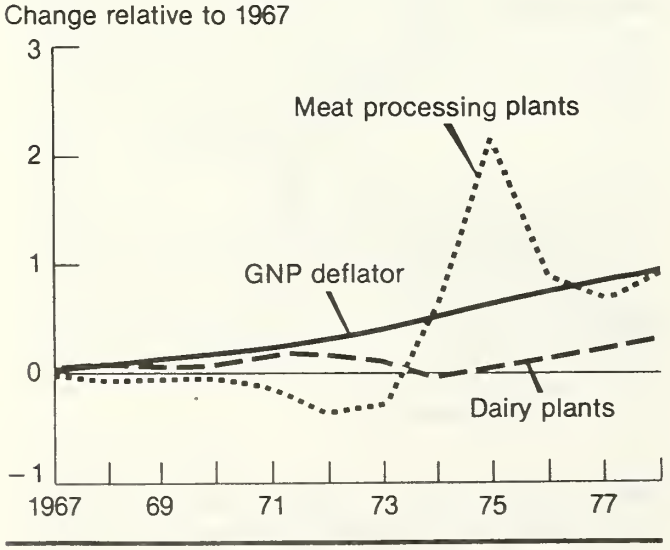
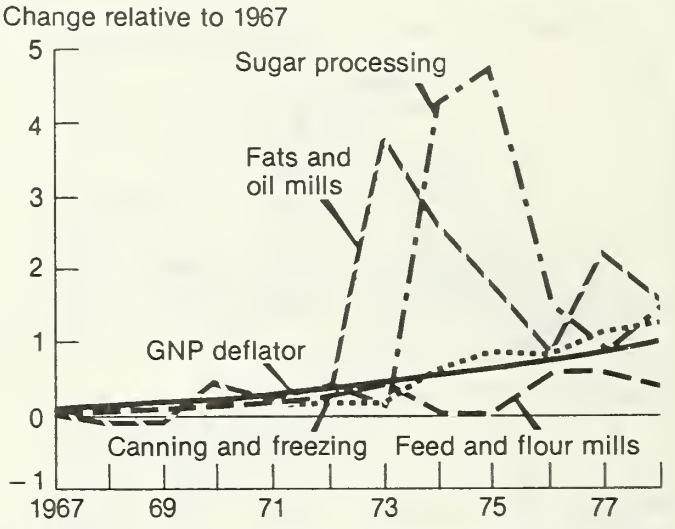


Figure 6

Changes in Income Due to Price Changes, Crude Crop Processing Sectors



The fats and oils refining sector exhibited a different pattern. Its income pattern roughly parallels that of the oil crop sector, which suggests that the sector is able to pass through increased raw material costs and a proportional margin to its customers, but the nature of the sector's supply and demand conditions does not allow it to maintain its output price when associated farm prices decline. An exception to this parallel pattern occurred in 1976 when the refining sector's income fell, while oil crops income rose slightly.

The sugar refining sector benefitted from large increases in world sugar prices in 1974, and it increased its income position slightly in 1975 when the sugar crop sector declined. By

Our model is useful because it shows which sectors of the food system have gained from the relative price changes accompanying the recent inflation and which sectors have lost.

1978, however, incomes in this sector had returned to a level about 145 percent above base level.

After a fairly stable, but increasing, income level during the 1967-73 period, the canning, freezing, and dehydrating sector income grew considerably during 1974 and 1975, weakened somewhat in 1976, and ended the period 111 percent above base level.

Highly Processed Foods

The three highly processed food sectors were relatively stable, exhibiting no abrupt annual fluctuations. For example, the confectioners and bakeries sector retained its 1967 income level throughout 1968; its income increased to 30 percent over base in 1969, then reached a 40-50 percent plateau where it stayed through 1973. After 1973, the sector income rose steadily for 2 years to a new plateau of 85-90 percent above base level in spite of high sugar prices. By 1978, its price-related income position was 103 percent above base level.

The income level of the flavoring and beverages sector was nearly constant from 1969 through 1973, rose sharply from 1974 to 1977, then dipped in 1978.

The miscellaneous food processing sector did not show strong income growth during the 1968-78 period.

Energy-Related Sectors

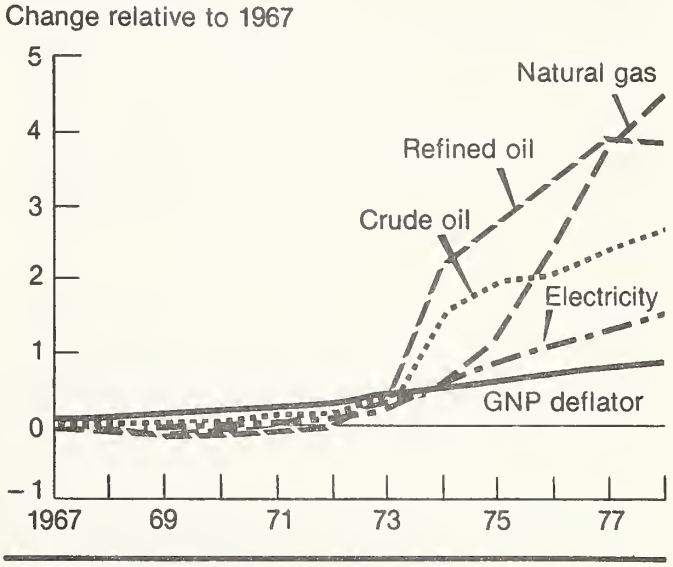
The plot of income due to relative price changes for energy-related sectors illustrates a pattern characteristic of the U.S. energy price situation. From 1967 to 1973, the real price of energy declined annually; after 1973, it rose to allocate tight supplies of oil and gas. The plot for the energy-related sectors (fig. 7) contrasts with plots for the farm sectors. Whereas the farm sectors did not retain any income peaks resulting from relative price shifts in their favor brought about by supply or demand shocks, the energy-related sectors have been able to retain income levels resulting from relative price changes.

Conclusion

Our model is useful because it shows which sectors of the food system have gained from the relative price changes accompanying the recent inflation and which sectors have lost.

Figure 7

Changes in Income Due to Price Changes, Energy Sectors



We have proposed, as a rough measure of the relative position of a sector with respect to inflation, its sector value-added price deflator relative to the GNP implicit price deflator. This comparison is available from the sector's value-added deflator lines and the GNP implicit price deflator in each figure.

Since 1973, except for feed crops in 1978 and food grains in 1977 and 1978, all export-oriented crops have exceeded the national norm (the implicit GNP deflator) and have benefitted from the relative price changes accompanying inflation by an amount likely to offset their less favorable position from 1967 to 1973.

Sugar has benefitted from the recent relative price changes accompanying inflation. Domestic-oriented crops have been relative losers. On balance, fruits, tree nuts, and vegetables have been relative losers. Since 1973, all the livestock sectors, except dairy in 1976 and 1977 and dairy and meat animals in 1978, have been below the national norm. From 1967 to 1973, the meat animal sector was a relative gainer, as were dairy in 1967-72 and poultry and eggs in 1967-70. The livestock sectors gained in the years when the general farm price

levels were rising slowly, but lost during the big farm price surge. Among livestock-product processing firms, the dairy food manufacturing sector has consistently been below the national trend. Meat and poultry processing was not only below the national trend but also below the base year during the 1967-73 period; it caught up with the national trend in 1974, was above it in 1975-1976, and below it in 1977-78.

Among the sectors processing crude farm crops, fats and oils mills have exceeded the national trend since 1970. Sugar refiners reached trend levels in 1970, and canning, freezing, and dehydrating reached trend levels in 1974. On balance, fats and oils mills and sugar refiners were gainers; grain mills were losers, and canners were unchanged.

Among the more highly refined food-processing sectors, confectioners and bakeries benefitted from relative price changes accompanying inflation, as have beverages and flavorings in recent years. The miscellaneous food processing sector has not benefitted.

Implications

Our results, which illustrate sector vulnerabilities to the relative price changes characterizing an economy adjusting to inflation, are not without lessons.

We have seen that if one uses the standard of the GFP implicit price deflator relative to the GNP price deflator, the farm sector has benefitted from relative price changes since 1972 (fig. 1). Previous studies of the effects of relative price changes on agriculture during the inflationary periods have not gone beyond the farm sector. Tweeten and Quance (*11*) found that farmers were disadvantaged by input price inflation. They concluded that a 10-percent increase in the Prices Paid by Farmers Index reduces nominal net farm income by 4 percent in the short run and by 2 percent in the long run. Tweeten and Griffin (*10*), updating this model, estimated that a 10-percent increase in farm input prices would reduce nominal net farm income 9 percent in short run, but would raise net farm income as much as 17 percent in the long run.

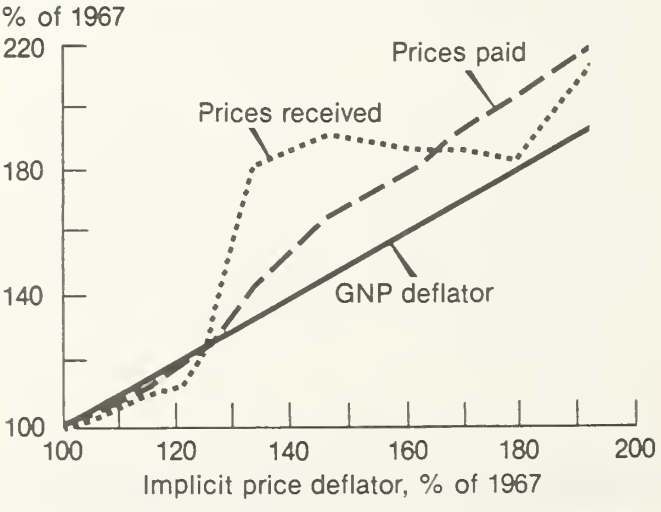
Other attempts to measure the effects of price changes on the farm sector during general price inflation have suggested that agriculture is always adversely affected. In a study which Ruttan characterizes as "the only rigorous empirical investigation of the effects of inflation on prices received and paid by farmers," Tweeten and Griffin (*10*) regressed the Farm Prices Received Index and Prices Paid by Farmers Index on the implicit GNP deflator and the lag of each variable for 1920-69. They observed a positive and significant relationship between the Prices Paid by Farmers Index and the implicit GNP deflator, but no significant relationship for the Prices Received Index. On this basis they concluded, "national inflation exerts a real price effect on the farming industry, reducing the parity ratio" (*10*, p. 10).

Because the Tweeten-Griffin results are based on price data similar to ours, yet arrive at the opposite conclusion, a further comparison of these two findings is in order. Some of the difference is explained by the different time periods. Tweeten and Griffin studied the 1920-69 period, whereas our study used the 1967-78 period. We suggest as an unproven hypothesis that the 1972-73 period, with its rapid expansion of agricultural exports and changes in the pricing policies of oil exporting countries, may have caused such fundamental shifts in relative price relationships as to invalidate many economic judgments for the post-1973 period, based on studies of time periods prior to 1972.

A second explanation is suggested by figure 8—that is, the Prices Received and Prices Paid by Farmers Indexes plotted

Figure 8

Farmers' Prices Received and Prices Paid Index Compared to the Implicit GNP Deflator



The first implication of our study, therefore, is to question the conventional wisdom about general price inflation having a negative real price effect on agriculture.

against the implicit GNP deflator. The prices paid line increases throughout the period and often nearly parallels the GNP deflator (45°) line. One would expect the Tweeten-Griffin result of a significant relationship between the Prices Paid by Farmers Index and the implicit GNP deflator. However, the Prices Received Index line both rises sharply and falls during the 1967-78 period and is hardly parallel. Again, one would expect the Tweeten-Griffin result of no significant relationship between the Prices Received Index and the implicit GNP deflator. But one would be misled by drawing a conclusion like Tweeten and Griffin's from these results: that is, general inflation reduces the parity ratio, because during this period, although the Prices Received Index varied too much to be signficiantly related to the GNP deflator, most of the variance was at a level above the GNP deflator.

Thus, during the 1967 period, while the general price level as measured by the GNP deflator rose each year and the rise totaled 92 percent, the parity ratio (1967 = 100) did not fall in 4 of the 11 years and fell only 4 percent over the 11-year period. The Tweeten-Griffin equations would have predicted an 8-percent drop, if one uses their insignificant coefficient in the Prices Received equation, and would have predicted a somewhat larger drop, assuming no relationship between the Prices Received Index and the GNP deflator. In 3 of the 4 years, the parity ratio did not fall; it rose 5 percent or more. The Tweeten-Griffin analysis does not consider the fact that, in recent times, supply and demand shocks on farm output prices have enhanced rather than depressed prices.

The first implication of our study, therefore, is to question the conventional wisdom about general price inflation having a negative real price effect on agriculture.

The proposed relative income index adds an analytical tool which measures the effect of relative price changes in greater detail than can the parity ratio. Our model allows the analyst to consider relative price effects on nonfarm sectors of the economy by keeping the individual sector measures consistent with national aggregate measures.

Ordinary price indexes are likely to mislead because they reflect only prices received or paid, but not both. The relative income index reflects net income after adjusting for prices received and paid by an individual sector.

Our model also demonstrates the effects of relative price changes on different sectors of the food system. Considering inflationary effects on either the food system or the farm sector masks the diversity in relative prices at the commodity and industry level.

Because inflation distorts investment decisions, capital values, and other time-related economic variables, the relative price effects presented here provide the policymaker with unique economic data. These effects are derived only from current flows from current production; thus, the relative measures of effects of relative price changes are not distorted by investment, cash flow, tax effects, and other time-related distortions.

References

(1) Heady, Earl O. *Agricultural Policy Under Economic Development*. Ames: Iowa State Univ. Press, 1962.

(2) Herman, Shelby. "The Farm Sector," *Survey of Current Business*, Vol. 58, No. 11, Nov. 1978, pp. 18-31.

(3) Holland, Forrest. "The Concept and Use of Parity in Agricultural Price and Income Policy," *Agricultural-Food Policy Review*, AFPR-1, U.S. Dept. Agr., Econ. Res. Serv., Jan. 1977.

(4) Lee, Gene K., and Gerald Schluter. "The Effects of Real Multiplier versus Relative Price Changes on Output and Input Generation in Input-Output Models," *Agricultural Economics Research*, Vol. 29, No. 1, Jan. 1977, pp. 1-6.

(5) Mitchell, W. "The Making and Use of Index Numbers," *Bulletin of the Bureau of Labor Statistics*, No. 173, pp. 5-114, July 1915, as quoted in Robert A. Jones' "Which Price Index for Escalating Debts," *Economic Inquiry*, Vol. XVIII, No. 2, Apr. 1980, pp. 221-32.

(6) Rasmussen, Wayne D., and Gladys L. Baker. *Price Support and Adjustment Programs from 1933 through 1978: A Short History*. AIB-424. U.S. Dept. Agr., Econ. Stat. Coop. Serv., Feb. 1979.

(7) Ruttan, Vernon. "Inflation and Productivity," *American Journal of Agricultural Economics*, Vol. 61, No. 5, Dec. 1979, pp. 896-902.

(8) Sato, Kazuo, "The Meaning and Measurement of the Real Value Added Index," *The Review of Economics and Statistics*, Vol. LVIII, No. 4, Nov. 1976, pp. 434-42.

(9) Stauber, B. Ralph, and R. J. Schrimper. "The Parity Ratio and Parity Prices," *Major Statistical Series of the U.S. Department of Agriculture*, Vol. 1: *Agricultural Prices and Parity*. AH-365. U.S. Dept. Agr., Oct. 1970.

(10) Tweeten, Luther, and Steve Griffin. "General Inflation and the Farming Economy." Research Report P-732. Oklahoma Experiment Station, Mar. 1976.
(11) Tweeten, Luther, and Leroy Quance. "The Impact of Input Price Inflation on the United States Farming Industry," *Canadian Journal of Agricultural Economics*, Vol. 19, Nov. 1971, pp. 35-49.
(12) U.S. Department of Agriculture, Statistical Reporting Service. *Agricultural Prices.* Selected issues.
(13) U.S. Department of Commerce, Bureau of Economic Analysis. "The Input-Output Structure of the U.S. Economy: 1967," *Survey of Current Business*, Vol. 54, No. 2, Feb. 1974, pp. 24-56.
(14) _____. *Survey of Current Business*, Vol. 56, No. 1, Part II, Jan. 1976, table 7.5; Vol. 59, No. 7, July 1979, table 7.5.
(15) Wharton Econometric Forecasting Associates. *Private Data Banks*. Philadelphia, 1980.

In Earlier Issues

Statistical demand analysis is a synthesis of several disciplines—economic theory, probability theory, and mathematical statistics—applied to concrete data. Each application requires special knowledge of the commodities involved and the adequacy of the statistical series which purport to measure their prices and quantities.

. . . No one of these specialties prepares [one] to give well-rounded advice to commodity experts concerning the statistical measurement of economic relationships. The verbal economist is too verbal; the mathematical economist too mathematical; and the statistician too disdainful of non-experimental data. In ignorance or desperation the commodity economist turns to empiricism, and it is too empirical.

Karl A. Fox
Vol. 5, No. 3, July 1953, p. 63

The Use and Misuse of Summary Statistics in Regression Analysis

By Robert V. Bishop*

Abstract

This article discusses the effect of an autocorrelated error structure on the interpretation of traditional significance tests, especially the t-test and R^2 measure. It emphasizes first-order serial correlation, a common and often serious problem that researchers using time series data may encounter. Even though many of the problems associated with an autocorrelated error structure are well known, many researchers ignore them and report results which range from being potentially misleading to grossly erroneous.

Keywords

Regression analysis, Autocorrelation, Filtering, Summary statistics

Introduction

In this article, I survey recent methodological developments concerning error structures which are "contaminated" with autocorrelation[1] and draw implications relevant for the interpretation and application of empirical econometric research.

It is common to find instances where researchers simply report Durbin-Watson statistics[2] that suggest an error structure which is first-order autocorrelated[3] without taking account of this when interpretating their results. A bias is introduced into the traditional tests of significance when autocorrelated errors are present;[4] this suggests that interpretation of these tests under autocorrelation is difficult, if not impossible. Furthermore, recognizing and correcting for first-order serial correlation with the usual Cochrane-Orcutt or Hildreth-Lu procedure is inadequate in certain rather common situations (*5*, *16*).[5]

If the error structure exhibits first-order autocorrelation and we assume that no relevant variable has been omitted,[6] the estimated regression coefficients are unbiased and consistent (as is well known), but they possess the undesirable property of being inefficient.[7] What is also well documented in the literature, but often overlooked in practice, is that the usual tests of significance, when performed in the presence of autocorrelated errors, are biased. For example, if positive first-order autocorrelation is present in the error structure and the independent variable is also autocorrelated, the estimates of the standard errors on each of the coefficients ($s_{\hat{\beta}}$) will be biased downward in most situations. When the standard error of the coefficient is underestimated, the *t*-statistic on that coefficient is obviously overstated as it is computed as $t = \hat{\beta}/s_{\hat{\beta}}$, implying greater explanatory power for that variable

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[1] By definition, autocorrelation is serial correlation in time series data. Serial correlation can also exist in cross-sectional data, such as spatial correlation (across geographic regions) or mutual correlation (across groups, such as income).

[2] The Durbin-Watson statistic (d) is computed as:

$$d = \frac{\Sigma(u_i - u_{i-1})^2}{\Sigma u_i^2}$$

This approximates $d = 2(1 - \rho)$ where ρ is the estimated first-order autocorrelation coefficient of the residuals in the model. As $\rho \to 0$, $d \to 2$. By examining a table for upper (d_u) and lower (d_l) bounds on this statistic for the appropriate degrees of freedom, the researchers can test the null hypothesis of no autocorrelation.

[3] First-order autocorrelation implies that the error term in period t is correlated with the error term in period t − 1, that is:

$$e_t = \rho e_{t-1} + u_t$$

where $E(e_t u_t) = 0$.

[4] The bias referred to here arises due to the consistent under- or over-estimation of the variances of the estimated coefficients. The estimation of the variance-covariance matrix of the estimators ($\hat{\beta}$'s) is computed as $s_e^2 (X'X)^{-1}$ which does not include the information embodied in the off-diagonal elements of the variance-covariance matrix of the disturbance terms commonly referred to as Ω in Generalized Least Squares applications. The true variance-covariance matrix of the $\hat{\beta}$'s is given by $s_e^2 (X'\Omega^{-1}X)^{-1}$.

[5] Italicized numbers in parentheses refer to items in the references at the end of this article.

[6] If a relevant causal variable has been omitted, the estimates are also biased.

[7] The properties of the estimators in the presence of autocorrelation are discussed in many good econometrics texts, for example (*10*, pp. 273-82).

than actually exists. This situation can easily lead to the inclusion of a statistically irrelevant variable in the final model. If the error structure exhibits negative serial correlation and the independent variable is positively autocorrelated, the standard errors of the coefficients are likely to be overestimated, possibly leading to the elimination of a statistically significant variable from the model.[8]

Granger and Newbold performed a series of tests in which they examined the potential for discovering "spurious" relationships due to problems with autocorrelated errors(*12*). They believed that much econometric work documented in the literature was permeated with "relationships" which existed due only to the researcher's failure to remove autocorrelation from the error structure. They examined the values of the coefficient of determination (R^2) generated by regressions in a Monte Carlo experiment. Two independent series were generated, one a random walk and the other a more complicated autoregressive, integrated, moving-average structure, specifically ARIMA (0, 1, 1) structure.[9] Granger and Newbold concluded that:

> It is quite clear from these simulations that if one's variables are random walks and one includes in regression equations variables which should in fact not be included, then *it will be the rule* rather than the exception to find spurious relationships. It is also clear that a high value for R^2 or $\overline{R}^2$ combined with a low value of *d* (Durbin-Watson statistic) is no indication of a true relationship (*12*).

In a later article, these authors further elaborated their position:

> In time series regressions involving the levels of economic variables, one frequently sees coefficients of multiple correlation (R^2) much higher than 0.9. If these indicate anything at all, they presumably imply an extremely strong relationship between the dependent variable and the independent variables. This is extremely misleading on many occasions, as comments noting poor forecast performance which sometimes follow these equations will testify. In fact, the high R^2 values could be no more than a reflection of the fact that the dependent variable is highly autocorrelated and could easily be achieved simply by regressing the variable on its own past. Thus, in such circumstances, the value of R^2 says nothing at all about the strength of the relationship between the dependent and independent variable (*13*).

If the error structure is first-order autoregressive (AR(1)),[10] the ordinary least squares (OLS) estimates of the regression parameters are (1) unbiased, (2) consistent, but (3) inefficient in small as well as in large samples. The estimates of the standard errors of the coefficients in a model are biased downward if the residuals are positively autocorrelated and the independent variable itself is positively autocorrelated; they are biased upward if the residuals are negatively autocorrelated and the independent variable is positively autocorrelated. Therefore, the calculated t-statistic is biased upward or downward in the opposite direction of the bias in the estimated standard error of that coefficient. Granger and Newbold have demonstrated that the R^2 measure (both adjusted and unadjusted)[11] is usually grossly misleading in the presence of an autocorrelated error structure (*12*). They have further suggested that the regression results can be defined as "nonsense" if the R^2 measure exceeds that computed for the Durbin-Watson statistic (*13*).

To demonstrate how misleading regression statistics can be, I offer an example. The natural logarithm of the quarterly measure of the U.S. consumer price index (CPI) was regressed on the logarithm of the narrowly defined U.S. money stock (old M1) for the period 1947-78. This is a test of a model describing the Crude Quantity Theory of Money, which states that changes in the exogenous money stock cause changes in the passive (endogenous) price level.

[8] One should not view negative autocorrelation as a mirror-image of positive autocorrelation. The different results obtained under positive and negative autocorrelation are due to the direction of the bias in the estimate of the standard error of the coefficients under the two conditions.

[9] A process characterized as ARIMA (0, 1, 1) is an integrated (regular differencing for stationarity is applied), mixed-autoregressive, moving-average model. ARIMA (0, 1, 1) implies no autoregressive parameter, one moving-average parameter, and one level of regular differencing. A good, though incomplete, introduction to time series modeling is contained in (*9*).

[10] An error structure that is AR(1) is one that exhibits only simple first-order autocorrelation.

[11] Adjusted R^2 or $\overline{R}^2 = 1 - (1 - R^2)\left\{(T - 1)/(T - K)\right\}$ where T = the number of observations and K = the number of estimated parameters in the regression. This adjustment is for degrees of freedom in the estimating equation that have been lost due to the inclusion of additional variables. This adjustment offsets the upward bias in the unadjusted R^2 which is most dramatic with a small sample size.

What is . . . well documented in the literature, but often overlooked in practice, is that the usual tests of significance, when performed in the presence of autocorrelated errors, are biased.

Table 1 presents estimation results which can be considered "nonsense results" (as defined above) as the magnitude of the $\bar{R}^2$ measure exceeds that computed for d (the Durbin-Watson statistic). Table 2 presents results using the same model but employing a simple first-differencing transformation[12] on the dependent and independent series. Letting M1* denote the transformed money series, first differencing is accomplished as $M1^*_t = M1_t - M1_{t-1}$. The Durbin-Watson statistic resulting from this estimation is higher than before but it is still very low; a fourth order autoregression[13] was performed on the residuals. The results of this autoregression indicate that the error structure is more complex than first-order autoregressive due to significant coefficients on the lagged terms of a lag greater than one.[14]

Table 1—Regression results of $ln(CPI_t) = f(ln(M1_t))$

Variable	Estimated coefficients	t-statistic
Intercept	−0.2878	1.42
ln (M1)	.9686	[1]21.92
Linear trend	−.0014	[1]3.64

Where: $R^2 = 0.98$
$d = 0.06$
$F = 6027$
SEE = 0.1771

[1]Significant at the 0.05 level.

Table 2—Regression results of $ln(P_t) - ln(P_{t-1}) = f(ln(M1_t) - ln(M1_{t-1}))$[1]

Variable	Estimated coefficients	t-statistic
Intercept	0.0024	1.61
$ln(M1_t) - ln(M1_{t-1})$	.1824	1.53
Linear trend	.0001	[2]3.47

Where: $R^2 = 0.15$
$d = 0.69$
$F = 21.7$
SEE = 0.0081

[1]Approximates: percentage change in price = f (percentage change in M1). Technically, the intercept term should have been omitted, as the intercept values (a vector of ones) have been adjusted by $1 - \rho$, which equals 0 if $\rho = 1$.
[2]Significant at the 0.05 level.

[12]First differencing of natural logarithms approximates a percentage rate of change.

[13] $e_t = \rho_1 e_{t-1} + \rho_2 e_{t-2} + \rho_3 e_{t-3} + \rho_4 e_{t-4} + u_t$

where $E(e_t u_t) = 0$.

[14]For a detailed explanation of one methodology for removing autocorrelation up to and including the fourth-order, see (2, pp. 11-14).

This example clearly demonstrates how sensitive the summary statistics of a regression can be to a first-differencing transformation. This is important both in testing the theoretical specification of the model as well as in forming expectations of its forecasting ability. For example, if one obtains an $\bar{R}^2$ of 0.99 from a model estimated by using levels, which is actually explaining only 30 percent of the variation in the dependent variable, the forecasting performance would fall far short of one's expectations. Yet, this "model" may be chosen over one estimated using first-differenced data because the $\bar{R}^2$ obtained in the former greatly exceeds that of the latter. The choice of the appropriate forecasting model between one estimated from levels and another from changes based on R^2 makes sense only if the R^2 measure truly attests to the model's explanatory power. If the model specification is correct, the choice will not matter—they will be identical. Presenting these results from raw data and not presenting the Durbin-Watson statistic would be deceptive at best and intellectually dishonest at worst. One must also recognize that a "good" Durbin-Watson statistic is insufficient evidence upon which to conclude that the error structure is "contamination free" in terms of autocorrelation, since it tests only for the presence of first-order autocorrelation.

Methods of Correcting for Autocorrelation

Assuming that evidence of first-order autocorrelation exists, one then asks what can be done to correct for it, or if correction is appropriate. A rather simple (but often effective) approach suggested earlier is to first-difference the data prior to estimation. This is equivalent to applying a general filter $(1 - \rho L)$, where L is a lag operator, so that $(1 - \rho L)X_t = X_t - \rho X_{t-1}$ and $\rho = 1$. This technique might alternatively be referred to as "pre-whitening" the input series, "filtering" the input series (or more correctly "pre-filtering" the input series), or "applying a first-difference transform" to the input series. Another possible method of eliminating first-order autocorrelation from the error structure is quasi-differencing," or applying the filter $(1 - \rho L)$, where $-1 < \rho < 1$. For example, if ρ is assumed to equal 0.75, applying the filter $(1 - 0.75L)$ to Y_t results in the transformed series Y* in which $Y^*_t = Y_t - 0.75Y_{t-1}$. The Cochrane-Orcutt iterative technique[15] estimates a value of ρ

[15]Initial and subsequent values of ρ are estimated by a first-order autoregression of the residuals resulting from an OLS estimation using the untransformed data.

$$e_t = \rho e_{t-1} + u_t$$

where $E(e_t u_t) = 0$.

using the residuals computed from a regression of the untransformed, or "raw," data. This technique can choose a value of ρ to satisfy the selection criterion of the computer algorithm but not eliminate the first-order autocorrelation in the error structure. This occurs when the estimation converges to a value that is a local, rather than a global, minimization of the sum of squared residuals. Another consideration arises if forecasts are generated from a model estimated with this technique as (1) the coefficient of the intercept and its standard error must be corrected,[16] and (2) errors in the forecast will tend to compound over time.[17]

Another technique available to the researcher is the Hildreth-Lu procedure, which uses values of ρ prechosen by the researcher. This technique is more robust against converging to an inappropriate value of ρ, but it is still vulnerable to the above two considerations if estimates derived from it are used for forecasting.

Analysis of Regression Residuals

Referring to the treatment of residuals in econometric models, Granger and Newbold state that:

> The traditional approach has been to assume first the residuals to be white noise[18] and to check this assumption by looking at the Durbin-Watson statistic, which effectively measures first-order serial correlation of the residuals. If evidence of significant first-order serial correlation is found, the residuals are assumed to be first-order autoregressive . . . there is little reason to suppose that the correct model for residuals is AR(1); in fact if the variables involved are aggregates and involve measurement error, an ARMA[19] model is much more likely to be correct (*13*, p. 9).

If the errors are characterized by a mixed, autoregressive, moving-average structure, time series modeling of the residuals can be employed following the methodology of Box and Jenkins (*3*). Although discussion of this technique is beyond the scope of this article, the researcher should be aware of this powerful and innovative approach.[20]

Wallis found that models which use quarterly data are often plagued by fourth-order autocorrelation, either when seasonally adjusted or when unadjusted data are used. He suggests that monthly or weekly models may also have a seasonal component remaining that can appear either as 12th- or 52nd-order autocorrelation in the error structure, respectively (*27*). We would not suggest that 12th- or 52nd-order prefilters should be constructed and applied to the data, but the residuals can be modeled, again using the techniques developed by Box and Jenkins (*3*) in which one can employ seasonal differencing to the residuals and then estimate the order of the autoregressive and moving-average components of the characterization. However, a more detailed discussion of this technique is beyond our scope here.

Pierce examines the issue of complex error structures, emphasizing the skepticism that experienced researchers exhibit when confronted with high R^2 measures (*22*). He notes that the R^2 measure is properly constructed as a measure of effects between variables, whereas in many applications, the measure is contaminated by within-variable effects. This is seen when lagged values in a relationship are combined with serial correlation in the dependent variable, which "means that part of the variance of y (the dependent variable) is explainable by its own past. This R^2 . . . will generally include effects attributable simply to lagged values of y" (*22*, p. 3). For this reason, Pierce asserts that the estimated R^2's using time series data exhibit much sensitivity to "prefiltering," which removes this within-variable effect.[21] Discussing the great difference between the apparent contribution to R^2 made by a lagged dependent variable expressed as a level (untransformed lagged dependent variable) and the contribution of that variable expressed as changes (that is, first differenced data), Pierce states, "this phenomonon results in an intrinsic ambiguity in conven-

[16] The estimate of the coefficient on the regular intercept must be multiplied by $1/(1-\rho)$ as must the standard error of that coefficient. The other estimated coefficients and the residuals are not affected.

[17] This is seen when we consider a forecast generated for one period into the future for some variable Y:

$$Y_{t+1} = a_1(1-\rho) + a_2(X_{t+1} - \rho X_t) + \rho Y_t$$

If Y_{t+1} is understated, Y_{t+2} will also be understated as Y_{t+1} enters the computation on the right-hand side.

[18] White noise implies that all the non-random components have been removed from the series and no additional "information" remains.

[19] *A*utoregressive *M*oving *A*verage model needing no regular differencing.

[20] This procedure attempts to explain the effects of variables which had been excluded from the model. One can argue that the parameter estimates thus obtained are more "proper." The forecasting performance is encouraging.

[21] The example here does not explicitly include a lagged dependent variable; however, the sensitivity of our example to prefiltering is obvious.

tional R^2 measures, and it is perhaps this ambiguity which underlies the rather limited faith often accorded these measures by persons experienced with time series data" (22).

Conclusion

Researchers are faced with considerable difficulty in interpreting the results of their modeling efforts. Measures computed from summary statistics, such as the coefficient of variation of the dependent variable (standard error of the estimate divided by the mean of the dependent series), are potentially meaningless. The explanatory power of the model based on the coefficient of determination may be grossly over- or understated. The variables included in the final model may be statistically irrelevant, or statistically significant variables may be excluded due to biased *t*-statistics. To protect themselves from being misled by their results, researchers must critically examine the error structure. The Durbin-Watson statistic should always be examined[22] as a bare minimum. Concurrently, researchers must be aware that this may not be sufficient to insure a meaningful interpretation of their results. Additional work in residual analysis is continuing with sophisticated techniques, such as time series modeling, and with analyses in the frequency domain that employ spectral techniques. There are no easy answers; researchers must address themselves to some of the complex issues described here if their research is to be useful to policymakers and to other researchers.

References

(1) Berndt, E. R., and N. E. Savin. "Estimation and Hypothesis Testing in Singular Equation Systems with Autoregressive Disturbances," *Econometrica*, Vol. 43, Nov. 1979, pp. 937-57.

(2) Bishop, R. V. "An Empirical Investigation into the Causal Relationship Between Money and Prices in the Post World War II United States." Staff report, U.S. Dept. Agr., Econ. Stat. Coop. Serv., Intnatl. Econ. Div., June 1980. Paper to be presented at the Midwest Economics Association Meeting, Louisville, Ky., Apr. 2-4, 1981.

(3) Box, G. E. P., and G. M. Jenkins. *Time Series Analysis.* San Francisco: Holden-Day, 1976.

(4) _____, and D. A. Pierce. "Distribution of Residual Autocorrelations in Autogressive-Integrated Moving Average Time Series Models," *Journal of the American Statistical Association*, Vol. 65, Dec. 1970, pp. 1509-26.

(5) Cochrane, D., and G. H. Orcutt. "Application of Least Squares Regression to Relationships Containing Autocorrelated Error Terms," *Journal of the American Statistical Association*, Vol. 44, No. 245, Mar. 1949, pp. 32-61.

(6) Durbin, J. "Testing for Serial Correlation in Least Squares Regression When Some of the Regressors are Lagged Dependent Variables," *Econometrica*, Vol. 38, May 1970, pp. 410-21.

(7) Engle, Robert F. "Specification of the Disturbance for Efficient Estimation," *Econometrica*, Vol. 42, Jan. 1974, pp. 135-46.

(8) Fuller, W. A., and J. E. Martin. "The Effects of Autocorrelated Errors on the Statistical Estimation of Distributed Lag Models," *Journal of Farm Economics*, pp. 71-82.

(9) Hammond, Elizabeth. "Forecasting the Money Stock with Time Series Models." Research Paper 7729. Federal Reserve Bank of New York, May 1977.

(10) Kmenta, Jan. *Elements of Econometrics.* New York: Macmillan, 1971.

(11) Granger, C. W. J., and M. J. Morris. "Time Series Modelling and Interpretation," *Journal of the Royal Statistical Society*, A, Vol. 139, Pt. 2, 1976, pp. 246-57.

(12) _____, and P. Newbold. "Spurious Regressions in Econometrics," *Journal of Econometrics*, Vol. 2, Mar. 1974, pp. 110-20.

(13) _____. "The Time Series Approach to Econometric Model Building," *New Methods in Business Cycle Research: Proceedings from a Conference*, Federal Reserve Bank of Minneapolis, 1977, pp. 7-22.

(14) Griliches, Zvi. "Distributed Lags: A Survey," *Econometrica*, Vol. 35, 1967, pp. 16-49.

(15) Henshaw, R. C., Jr. "Testing Single-Equation Least Squares Regression Models for Autocorrelated Disturbances," *Econometrica*, Vol. 34, July 1966, pp. 646-60.

(16) Hildreth, C., and J. Y. Lu. "Demand Relations with Autocorrelated Disturbances." Technical Bulletin 276. Michigan State Univ., Agricultural Experiment Station, 1960.

(17) McLeod, A. I. "Distribution of the Residual Cross-Correlation in Univariate ARMA Time Series Models," *Journal of the American Statistical Association*, Vol. 74, Dec. 1979, pp. 849-55.

[22] If a lagged dependent variable is included, the Durbin-Watson statistic is biased toward 2 and is, therefore, more difficult to interpret. If it is very low (near 0) or very high (near 4), the residuals are most likely autocorrelated. If the sample size is large, one can construct a modified *h*-statistic to test for autocorrelation in the presence of a lagged dependent variable. See (*6*).

(18) Maddala, G. S. *Econometrics*. New York: McGraw Hill, 1977.
(19) _____, and A. S. Rao. "Tests for Serial Correlation in Regression Models with Lagged Dependent Variables and Serially Correlated Errors," *Econometrica*, Vol. 41, July 1973, pp. 761-74.
(20) Nelson, C. R. *Applied Time Series Analysis for Managerial Forecasting*. San Francisco: Holden-Day, 1973.
(21) Nerlove, N., and K. Wallis. "Use of Durbin-Watson Statistic in Inappropriate Situations," *Econometrica*, Vol. 34, Jan. 1966, pp. 235-38.
(22) Pierce, D. A. "R^2 Measures for Time Series," *Special Studies Papers 93*. Federal Reserve Board of Governors, Oct. 1978.
(23) Rao, P., and Zvi Griliches. "Small-Sample Properties of Several Two-Stage Regression Methods in the Context of Autocorrelated Errors," *Journal of the American Statistical Association*, Mar. 1969, pp. 253-72.
(24) Saracoglu, R. "The Maximum Likelihood Estimation of Parameters in Mixed Autoregressive Moving Average Multivariate Models." Staff Paper 20. Federal Reserve Bank of Minneapolis, Apr. 1977.
(25) Theil, H., and K. Clements. "Recent Methodological Advances in Economic Equation Systems." Unpublished paper, 1979.
(26) Tillman, J. A. "The Power of the Durbin Test," *Econometrica*, Vol. 43, Nov. 1975, pp. 959-74.
(27) Wallis, K. F. "Testing for Fourth Order Autocorrelation in Quarterly Regression Models," *Econometrica*, Vol. 40, July 1972, pp. 617-36.

In Earlier Issues

It was out of the effort to understand the conditions of agriculture and farm people that agricultural economics developed, and this is the driving force that has maintained the life of the science.

Oris V. Wells
Vol. 5, No. 1, Jan. 1953, p. 2

Advertising, Promotion, and Competition: A Survey with Special Reference to Food

By John M. Connor*

Abstract

This article surveys the theoretical and empirical literature on the economics of advertising during the last decade. The survey notes several promising advances in theoretical modeling of the role of advertising in consumer choice and social welfare. Numerous empirical investigations of food and other consumer products have established relationships between advertising and market structure or performance indicators. Less progress was found on selected socioeconomic advertising issues that are difficult for traditional economics to handle.

Keywords

Advertising, Sales promotion, Market structure, Performance, Welfare economics, Consumer choice

Introduction

The study of the economic role of advertising began only 30 years ago with a seminal paper by Kaldor (*14*).[1] Analytic modeling of advertising and related forms of sales promotion has proved arduous and nearly intractable. The first crude empirical tests of hypotheses about advertising began only 15 years ago. During the last 10 years, substantial progress has been made in both the theoretical and empirical economic literature.

In this article, I survey recent analyses of the economic role of advertising and other types of sales efforts, focusing especially on the socioeconomic and welfare effects of advertising. I consider the role of advertising in determining the quality of competition in markets for food and other grocery products. The most recent survey of the welfare effects of advertising is an article by Doyle (*10*), written in 1968. Shaffer has also thoroughly surveyed the role of advertising in food marketing firms (*38*). However, both articles are in part dated.

After examining the conventional distinction between advertising as information and advertising as persuasion, I discuss several socioeconomic issues surrounding advertising and survey the evidence regarding five separate welfare economics issues. I conclude by assessing the literature and making suggestions for future research.

Information versus Persuasion

Sellers differentiate their products from those of rival sellers in four main ways: space, form, service, and image. Spatial differentiation occurs through selecting convenient plant or store locations. Form differentiation occurs when products are altered physically to create differences in shape, flavor, color, durability, storability, ingredients, or packaging. Service differentiation is common in retail trade or in a product that requires repairs during its usable life. Image differentiation involves the subjective impressions of consumers about a particular product, such as the kind of person who typically uses that product. Image differentiation often occurs in conjunction with one or more of the other three kinds of differentiation. Labeling, packaging, and advertising are the principal means of image differentiation of products.[2]

It is true that some, perhaps most, advertising provides information about the tangible, objective characteristics of products or services offered for sale, facts that aid buyers in conscious, rational decisionmaking. Informational cues on ingredients, durability, points of purchase, and price are characteristics of classified advertising, trade publications, and catalogs. However, much advertising content appears to be primarily "persuasive" messages that are highly subjective, emotive, or even subconscious in their appeal. Most advertising through the mass media (particularly the elec-

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[1] Italicized numbers in parentheses refer to items in the references at the end of this article.

[2] Enterprises can also create images which affect their product or service offerings. Enterprise differentiation occurs mainly through spatial or service differentiation. Food retailers, for example, employ store decor or color schemes, check-cashing services, nutrition counseling, unique private-label products, and other devices to differentiate their enterprises. Diversified food manufacturers, in contrast, usually offer a multiplicity of brands that discourages the development of a company-wide consumer image.

tronic media) is preponderantly persuasive. Other mass-media advertising contains a more equal mixture of informative and persuasive elements; newspapers, billboards, and magazines are often of this type (*35*). Some forms of sales promotion are largely persuasive (coupons, sweepstakes, and incentives), whereas others are partly informative (free samples and sales demonstrations).

The proportion of information contained in advertising varies not only by medium but also by type of product. Some products have been associated with historically intense and uninformative advertising. Items relating to personal care (razors, soaps, and deodorants) are susceptible to advertisements emphasizing the product's ability to reduce feelings of personal insecurity. The advertising of luxury products, like perfumes, furs, or jewelry, is oriented toward increasing social status. Some foods and beverages have lost their function as necessities or sources of nutrition alone. "Dietetic" foods and chewing gum, for example, are valued less for their life-sustaining attributes than for their organoleptic properties. Many foods are consumed in a convivial or ceremonial setting and are thus more prone to highly persuasive advertising. There is a world of difference between a sack of flour and a bottle of champagne in their potential for being image-differentiated.

Most packaged and branded grocery items have properties that lend themselves to substantial advertising expenditures relative to sales. One of the most comprehensive studies of the determinants of advertising intensity was recently published by Farris and Buzzell (*11*). Based on the internal records of 281 consumer lines of business, they found that the ratio of advertising and promotion expenditures[3] to sales was positively and significantly related to: standardization (not special-ordered), infrequency of purchase, small unit-purchase value, proportion of sales to distributors (as opposed to direct sales to final consumers), and proportion of new products marketed by the business. Except for infrequency of purchase, all these characteristics are typical of packaged, branded grocery products. Consequently, the advertising intensity of processed food and tobacco products is relatively high. Media advertising by food manufacturers alone averages well over 3 percent of sales if one excludes highly perishable products; food retailers spend an additional 1 percent of their sales on advertising (*7*). Other forms of sales promotion such as coupons, incentives, samples, and some direct sales force activity would probably raise the intensity of advertising to 8 percent of sales.

The informative content of advertising is at the heart of discussions on the social and economic value of advertising. Theories of advertising developed by Stigler (*41*), Telser (*43*), and Nelson (*22*) assume that consumer experience with a product should either reinforce correct prepurchase information or invalidate false information. The market will immediately discipline all false advertising through a loss of market share to sellers. Moreover, these theoretical models conclude that firms with unknown products and those offering the best quality/price combination are the ones that advertise most. With purely factual or informative advertising, the effects of advertising are uniformly welfare-enhancing. Consumer search costs would be significantly lower with informative mass advertising than with searches involving individual trial consumption or testing. As sellers have no incentive to deceive with advertising, the Stigler-Telser-Nelson models imply that competitive market performance is enhanced if consumers simply choose the most heavily advertised products.

Little empirical evidence exists on the informative content of advertising, but one initial effort indicates very low levels for television advertising.[4] Resnik and Stern (*31*) examined 378 randomly selected television commercials (78 percent of which were grocery products) for 14 different informational cues. Only 45 percent of the commercials for grocery products contained even one informational cue; the rest were devoid of informative content. Preliminary results of research by the same authors on other media indicate a higher proportion of informative advertisements. Empirical evidence combined with more recent theories cast some doubt on the sanguine conclusions of the Stigler-Telser-Nelson research. More recent models generally assume that consumers cannot costlessly and immediately validate the quality of a purchased product with absolute certainty. Kotowitz and

[3] These expenditures included media advertising, catalogs, exhibits, premiums, coupons, free samples, and special promotional discounts. The costs of field sales forces were not included.

[4] Parker and Connor (*26*) calculated that in 1975 approximately one-fifth of all mass-media advertising expenditures for all (SIC 20) manufactured foods was "excessive"—that is, noninformative. Their method, admittedly highly conjectural, divided the 130 food product classes into those that were competitive and those that did not meet the competitive concentration standard (40 percent four-firm seller concentration ratio or less). They then calculated the informative advertising-to-sales ratio for those classes (0.53 percent) and netted that amount from all other product classes. The remainder was considered excessive. Kaldor (*14*) independently arrived at a similar information proportion of advertising costs.

Mathewson (*15*) have investigated the relationship between "correct" (nondeceptive) advertising and monopoly. Their theoretical model assumes the existence of a nondiscriminating monopolist and consumers whose consumption is affected positively by the consumption of other consumers (the "demonstration" effect). Under these conditions, the equilibrium result is that the seller expends more than the socially optimal amount on advertising and simultaneously provides too little total information to consumers. This model demonstrates a key link between advertising, informative content, and the welfare effects of imperfect competition.

When consumers are imperfectly informed about products, the market does not maximize social welfare. Smallwood and Conlisk (*39*) have presented a model in which consumers know the price of products and the prices of all brands are held equal, but consumers are uncertain about product quality until use (that is, inspection prior to consumption cannot reveal quality, as is true of most packaged consumer goods). Smallwood and Conlisk's model, built on an adaptive dynamic search strategy, results in alternative equilibria, two of which are interesting. First, even though prices are the same, equilibria exist for which several different quality levels of products survive in the market. Second, it is possible, under some reasonable conditions, for a brand of "inferior" quality with an initially high market share to capture the entire market over time.

A second article by Kotowitz and Mathewson (*16*) is also based on a consumer adaptive-search strategy. Their model assumes that: (1) rational consumers are ignorant, but tractable, about product quality; (2) tastes are formed and fixed with respect to product attributes; and (3) advertising does not alter tastes, but does alter perceptions about a quality attribute that requires continuous, prolonged experience to evaluate. In this model, while false advertising claims are eventually invalidated, the speed of discovery depends on the consumer's ability to learn and remember. It can be profitable in the long run for a monopolist to mislead consumers, at least for a period of time, by giving them incorrect quality information. Although the authors cannot make any unambiguous welfare conclusions for marginal consumers, all inframarginal consumers experience a loss because the monopolist substitutes advertising claims about product quality for true quality.

Unresolved Issues

There are several issues related to the perceived social effects of advertising. Some lie outside the traditional domain of economics. The rest are basically unresearched questions. In general, less progress can be cited in settling these issues than the welfare economics issues I discuss later. However, the topics are sufficiently important to be considered here.

First, it is sometimes claimed that advertising increases macroeconomic stability because of countercyclical advertising expenditures by sellers and the resulting stabilization of consumer aspirations over time. Scherer's (*35*) survey of this issue finds that advertising expenditures show a definite procyclical pattern. Moreover, empirical studies of the effects of advertising on aggregate consumption have yielded inconsistent results. Thus, the evidence on dynamic stabilization is inconclusive.

Second, some of the "information" conveyed by advertising is deceptive or at least misleading in a legal sense. There are voluntary U.S. industry groups whose regulations limit deceptions, such as the National Advertising Review Board. State and Federal Government agencies enforce laws against deceptive and fraudulant advertising claims. Although these efforts have largely eliminated blatant deception, omission of relevant facts, innuendo, obvious exaggeration, and puffery are typical features of modern advertising. Preston's book on puffery (*29*) cites scores of examples of food advertisements containing puffery statements like "Milwaukee's finest beer," "the biggest little treat in all the land," and "every body needs milk." Such phrasing is not illegal, but Preston argues that it may mislead some consumers and must have some effect on purchasing patterns. At least, the frequency with which such seemingly irrefutable phrases appear in advertising copy arouses cynicism among some sellers and consumers about the truthfulness of advertising (*35*, p. 380).

Third, advertising is criticized sometimes for instilling or entrenching hedonistic values. Food advertising, for example, often omits facts about health or nutrition but includes assertions about sensual characteristics. Some critics perceive a connection between the rise of hedonism and the appearance of modern advertising in Western societies. Yet counter-examples also abound (wartime exhortations, antismoking campaigns), and Scitovsky (*37*) has woven an elegant argument that, despite high levels of advertising, U.S. consumers habitually underachieve in pleasure-seeking relative to citizens of other countries.

Fourth, advertising may substantially affect national food choice. By raising prices on heavily advertised products, many consumers are forced to substitute less desirable brands in the same product category. Advertising probably shifts

interindustry demand as well as interbrand demand in the long run. Advertising may be partially responsible for the notable shift in preference away from milk, fruit juices, and water (which are less advertised) to artificially fruit-flavored drinks, soft drinks, tea, and alcoholic beverages (all of which are heavily advertised). Indeed, Mottern (*19*) has presented some evidence suggesting an association between heavy advertising and poor nutritional characteristics of foods.

Finally, there is the question of interdependent utility functions. Much advertising seeks to lead consumers to compare their own well-being with that of other consumers; it urges them to emulate the consumption patterns of those they admire. Consumer utility thereby depends on others' perceived consumption habits as well as on the intrinsic characteristics of the products or services, thus generating external effects in consumption. Thus, some advertising first creates *dissatisfaction* in potential consumers which can only be removed by purchasing the advertised commodity, bringing consumers back to their original level of satisfaction (prior to the assault on their preference structure by the advertising). It is doubtful that advertising which contains only messages of status discontent can ever result in a net increase in consumer satisfaction.

Issues of Welfare Economics

Doyle (*10*) has identified five major issues of welfare economics involving commercial advertising, especially the persuasive kind:

1. Its relationship to monopoly market structures, especially barriers to entry, and concentration;
2. Its impact on profits, prices, market share stability, and other indicators of market power;
3. Whether it stimulates or retards technological progress;
4. Its relationship to guarantees of product quality;
5. The extent to which it cross-subsidizes the entertainment media.

Market Structure

Here we consider the relationships of advertising and promotion to concentration, economies of scale, and other barriers to entry. Empirical tests of relationships have frequently used the ratio of media advertising to sales as a proxy for the degree of product differentiation, assuming that other sales promotion efforts are correlated with advertising. The advertising-concentration relationship is one of the oldest and most frequently examined topics in industrial organization research. A recent survey by Comanor and Wilson (*5*) concluded that the direction of causality depends on the samples or time period studied. A recent test by Ward and Behr (*44*) found a strong positive relationship for consumer nondurable industries in several time periods; an examination of the food industries failed to find any difference from the consumer nondurable industries. Using a simultaneous-equations model of structure and performance in the food manufacturing industries in 1967 and 1972, Pagoulatos and Sorenson discovered that advertising intensity was strongly and positively associated with market concentration (*25*). Analyses of concentration and advertising intensity are incomplete in indicating the level of competition because the level also depends on the existence of nonadvertising barriers to entry.

Advertising may be related to another element of market structure—economies of scale in production. It has been agrued that advertising expands a firm's sales and thereby allows attainment of the optimal scale of production. Neither Scherer (*35*) nor Doyle (*10*) believes there is any empirical evidence for this hypothesis; indeed, given that advertising intensity is related to physical product differentiation, numerous product varieties, planned obsolescence, and consequent short production runs, the reverse is likely true. Connor (*6*) has established that brand proliferation among processed foods is significantly and directly related to media advertising intensity. However, these findings refer to single-plant economies; it is possible that advertising and promotion may give rise either to pecuniary advantages to size or to multiplant economies of scale. Scherer and others suggest that, for two grocery-products industries, optimal U.S. multiplant scales are reached at the two- to five-plant level due to advertising and image differentiation alone.

Most research points to substantial economies of scale in advertising itself. That is, as the amounts of advertising and promotion inputs in a firm are increased proportionately with other production and marketing inputs, output (sales) increases more than proportionately over a certain range. Strong evidence exists for substantial economies of scale for beer (*27*) and cigarettes (*2*).[5] For a large sample of consumer-product lines of business, Farris and Buzzell (*11*) found that market share was inversely related to the intensity of adver-

[5] Advertising capital is used in these studies. For foods and most consumer nondurables, annual depreciation rates were found to be in the range of 30-80 percent.

The available evidence supports the hypothesis that high advertising intensity leads to above-normal profits in food manufacturing; however, comparable studies are not available for other stages of the food marketing system.

tising, even after controlling for several other factors. *The Nielsen Researcher* (*24*) found that brand market share and brand advertising share were positively and closely correlated for 60 grocery store brands in 20 product classes; however, except for brands with a low-price image, advertising share tended to exceed market share. Economies of scale in advertising arise from two principal sources: pecuniary and technological economies (*4*). First, volume discounts appear to persist for specific kinds of media advertising, particularly the electronic media and national magazines. Also, some media events—for example, the Olympics—are lumpy (infrequent and unusual), which can give advantages to the leading firms in an industry when bidding for choice advertising slots. Second, advertising effectiveness (the number of messages of equal buyer impact) may be less expensive at larger volumes than smaller. Sometimes this effectiveness can be attributed to the use of national rather than local media, to the existence of a threshold effect in advertising, or to the advantages of having a "full line" of products over which the advertising of a limited number of brand names can be spread.

Economies of scale in advertising imply substantial barriers to entry by small firms. Their successful entry will require much higher advertising-to-sales ratios initially than those for the established firms in a market; the costs may be so high that entry is unprofitable for months or years. Moreover, introducing one brand into a consumer goods market on a national scale may require an initial advertising and promotion budget of several million dollars (*7*). Financial institutions will not usually lend a newcomer funds for this purpose; hence, new-product launches can constitute an absolute capital barrier to entry. Large or diversified firms are the principal sources of new food products, and their relative ease in overcoming promotional entry barriers is doubtless one of the reasons (*6*).

The general conclusion about advertising as a cause of high entry barriers must be modified for retail and service operations (*4*, *35*). This qualification rests mainly on research comparing prices and quality of optometry services across cities with different rules governing advertising. Prices are significantly lower in areas permitting advertising, whereas few differences existed in the quality of the goods and services (*1*). Thus, advertising by food retailers may aid entry, but there are as yet no specific studies on this subject.

Ultimately, the most important impact of advertising on competition may be on the longrun alteration of market structures. In one detailed study, Mueller and Rogers examined the relationship of advertising to changes in seller concentration in the U.S. manufacturing industries (*21*). Recently replicated for the food industries by Rogers (*32*), these results indicate that, *ceteris paribus*, intensive advertising (especially on radio and television) caused concentration to rise over the 1958-72 period. Without advertising, "natural" competitive forces would have eroded market concentration. Mather's study in 1979 provides some insight into one type of conduct associated with concentration change (*18*). His study of 68 mergers of food firms during the 1967-76 period confirms that advertising expenditures rose more than 50 percent in the 2 years following the merger, especially after product-extension type mergers. Taken together, these last two studies suggest why conglomerate mergers involving consumer goods firms may restructure markets.

Price and Profit Performance

Advertising intensity, while not an entirely satisfactory proxy, has been used to represent the extent of product differentiation in a market. It is also associated with basic product characteristics, such as durability, consumer versus producer goods distinction, industry media choices, and manufacturer-retailer power relationships. The most rigorous studies indicate that both brand and industry price elasticities of demand are lowered by advertising. That is, advertising creates consumer loyalty, reinforces repeat-purchasing patterns, and allows firms to raise prices (within limits) relative to those of rivals with little erosion of sales. Over time rival firms may respond with advertising campaigns of their own to preserve their share of the market and maintain their profits. In an oligopolistic market,[6] strategic considerations lead to a situation in which firm advertising expenditures are made largely to cancel out rival advertising messages. Under pure monopoly or perfectly coordinated, joint-profit maximization, total advertising expenditures would be much lower than in a loose oligopoly (*35*). Some of these considerations may underlie the voluntary advertising restrictions in some industries, such as the U.S. liquor industry.

Firm or brand loyalty combined with effective market-entry barriers can insulate firms from competition. The existence of market power can be inferred from studies showing that high profits are positively and significantly related to concentration, advertising, and other market structure dimensions. Many such "profits-structure" studies have been performed for the manufacturing industries; four of these have examined the advertising-profits relationship for the food manufacturing

[6] One in which a few sellers dominate.

industries. Parker and Connor (*26*) found that advertising intensity had significant, positive effects on the 47 food industries' price-cost margins for 1972. Using 1950-54 data, the Federal Trade Commission (FTC) (*12*) found the same strong relationship from the 97 largest food manufacturing firms. Using 1967-72 data, Rogers (*33*) replicated these results for a similar sample of 60 firms. A fourth preliminary study, using a simultaneous equation model, estimated a significant, positive impact of advertising and concentration on profits for the food processing industries in 1967 and 1972 (*25*). The available evidence supports the hypothesis that high advertising intensity leads to above-normal profits in food manufacturing; however, comparable studies are not available for other stages of the food marketing system.[7] These strong results are consistent with an important analysis by Porter that found that both the concentration-profits and advertising-profits relationships were strongly positive in those manufacturing industries marketing their products through self-service stores like grocery stores (*28*).

By conferring market power on firms, advertising should lead to higher prices in the affected markets. Price enhancement has traditionally been more difficult to establish because appropriate price data are lacking. However, one empirical test relates the 1976 prices of a large sample of advertised processed foods to market structure and other factors; the standards of comparison were the prices of equivalent private-label foods, which were assumed to be produced by sellers and distributed through channels devoid of market power (*26*). Results showed that, *ceteris paribus*, media advertising intensity had a significant, positive impact on wholesale prices; for each 1-percent increase in the advertising-to-sales ratio, wholesale prices rose about 0.9 percent. Furthermore, the proportion of network television advertising relative to total eight-media expenditures had a significant, positive impact on prices. On average, processed, branded food prices were approximately 8.5 percent higher than private label equivalents because of media advertising alone.[8] This is considerably less than the price differentials for specific, highly advertised, high market-share grocery products cited by Scherer (*35*).[9] It is more than the 2-percent differential to all consumer produce reckoned by Doyle (*10*). Similar studies of retail grocery prices have not considered the effects of retailer advertising on prices. Spatial and service differentiation (wide aisles, modern stores, and in-store delicatessens) are probably more important determinants of store-to-store price differences within single markets *(17)*.

Market share mobility is an indicator of industry performance. Generally, data on market-share changes are difficult to obtain; when employed, they should be confined to a single market and should represent a total firm's share of the market. Using reliable data, Reekie found that market share instability among 34 finely defined, food product classes was significantly and positively related to advertising intensity (*30*). This study's results are contrary to all the other findings on profit and price performance quoted above, but because Reekie used brands rather than firm shares and failed to control for new product introductions, the findings should be verified with others before being accepted.

Technological Progressiveness

The concensus of the most recent, rigorous empirical studies of technological progressiveness is that a low to moderate amount of market power optimizes the rate of progress (*35*). These studies typically measured technological output by research and development (R & D) expenditures (really an "input" measure), patent awards, scientific publications by employees, or similar measures. Moderate firm size and some degree of market concentration are held to reduce the risk associated with returns to R & D effort; these factors may also enhance a firm's cash flow, part of which can be diverted to R & D uses. Of course, factors other than market structure, such as technological opportunity, also play a role in determining technological advancement.

To the extent that advertising reduces unpredictability in a firm's market environment, it may also encourage technological output, especially advertising associated with the introduction of new products (*35*). Doyle (*10*) argues that nonadvertising factors are stronger influences over all.

Only one empirical study is available on the progressiveness-advertising relationship for food manufacturing firms. Mueller, Culbertson, and Peckham (*20*) used individual firm data from two periods, 1950-56 and 1967-74. They employed three measures of progressiveness: R & D expenditures, R & D

[7] The FTC study found that profits on assets were raised by about 1.1 percentage points for each 1-percent increase in advertising-to-sales ratio. Rogers' results were about 1.5 points on assets; Pagoulatos and Sorensen calculated a 1.1- to 1.0-percentage point increase in sales, whereas Parker and Connor's results were 2.9 percentage points of sales. These elasticities were calculated at the approximate mean values for the advertising-to-sales ratios.

[8] Average four-firm media advertising-to-sales ratios were 2.7 percent, and the average network TV proportion was 0.35 percent (*26*, table 3).

[9] The examples mentioned by Scherer include; Realemon (30 percent higher), Clorox bleach (45 percent), and a study of 217 drugs (67 percent higher).

Results showed that . . . media advertising intensity had a significant, positive impact on wholesale prices; for each 1-percent increase in the advertising-to-sales ratio, wholesale prices rose about 0.9 percent.

employment, and patent output. Their results showed that the advertising-to-sales ratio had a significant, positive influence on progressiveness in the latter period; for patent output, advertising intensity peaked at about 7 percent. As expected, firm size, diversification, and concentration were consistently significant factors; firms with about $125-$150 million total assets (1967 dollar value) had the highest rate of technical output.

Product Quality

Some image differentiation may be necessary to motivate manufacturers or distributors of consumer goods to maintain adequate quality standards. Simple trademarking or labeling may be sufficient to ensure minimal quality standards for repetitively purchased goods (*35*). But mere brand identification or familiarity require only minimal levels of advertising or sales promotion. Whether consumers can use heavy promotion as a guide to high quality products is seriously doubted by most economists (*10*). No doubt, for some products, many consumers use heavy advertising as well as high prices as a sign of high quality. Double-blind experiments of some food products have shown that consumers usually cannot distinguish average-priced from premium-priced items (*35*, p. 382). Thus, their willingness to pay higher prices for more expensive equivalents is apparently due to the aura, image, or status associated with the brand. Shaffer has called this the placebo effect of advertising (*38*).

If price differences between national brands and first-line, private-label food products are any guide, consumers are willing to pay 10-15 percent more for the national brand (*17*). Some consumers may choose more expensive versions because of perceived risk-aversion; that is, private-label products may be of equivalent quality on average, but their quality may be more variable. Some consumers may try one of the earliest brands to appear on the market, identify its particular configuration of characteristics as the standard of quality, and continue to purchase the original product because succeeding brands seem "different." Such habituation processes are well understood in the field of psychology, but have not been well integrated into economic models of consumer behavior (*40*).

Evidence on quality differences among brands of foods in the same product categories is scanty; moreover, such data as do exist depend on subjectively chosen weights for each characteristic comprising the overall quality index. One way of calculating quality is to compare national brand foods with private-label imitations. Parker and Connor (*26*) reviewed data from laboratory-type tests and found no systematic quality differences. Another source of quality comparisons is the Consumers Union (*8*), whose tests combine objective physical measures of food quality (size uniformity, color intensity, and viscosity) with blind tastings by a consumer panel (for flavor retention and ingredient balance). Test results over the years have indicated few differences in average quality between national brands and the first-line, private-label products.[10] The main differences appear to be price, packaging, and advertising.

Media Cross-Subsidization

The subsidization of news and entertainment in the mass media is perhaps advertising's major benefit to consumers. In the United States, about 70 percent of gross newspaper revenues, over 50 percent of general periodicals revenues, and virtually all revenues of the commercial radio and television networks come from advertising (*35*). After deductions for increased costs due to producing the advertising space or time, these media still have a net subsidy.

Cross-subsidization is not a net loss to consumers who pay for advertising through their purchases; it is primarily a transfer payment. Doyle (*10*) believes that income is transferred from the rich to the poor through the cross-subsidization of television, but the redistribution is regressive for newspapers. Nonusers of the mass media lose the most. Heavy users of subsidized media who enjoy advertising as a craft or diversion gain the most.

Finally, because advertising is a joint product with the media, there is no separate market for evaluating advertisements. Excessive social investment in advertising is likely in some media (*28*), especially those associated with oligopoly (*9*).

Conclusions

Theoretical models of consumer choice, monopoly, and welfare and their relationships to advertising became increasingly rigorous during the seventies. Along with analytical rigor has come the necessarily restrictive assumptions that blunt the generality of the models' conclusions. Notable advances have been made in modeling the psychological process of habituation within an adaptive-dynamic framework, but other psychological aspects of consumer choice have not yet been incorporated; the "placebo" effect of advertising is an example. The concept of advertising as af-

[10] "Generic" private labels generally test out at a lower-quality level.

fecting consumer perception of product-quality attributes seems more promising than were earlier treatments of advertising as an influence directly affecting the structure of individual tastes. Finally, further refinements may be needed for the distinction between the informative versus the persuasive content of advertising and the treatment of product quality.

The empirical tests of the past decade have filled a void. Most previous research on advertising, including that by the U.S. Department of Agriculture (for example, *23*) dealt with measurements of the sales-increasing effect of advertising. Research on advertising effectiveness is currently carried on by marketing economists in business schools, corporate economists, or researchers concerned with generic advertising (for example, *45*). Research on the industrial organization aspects of advertising has reached fairly sophisticated levels regarding data reliability and methodological refinements. Attempts to measure the informative content of advertising, however defined, and the welfare benefits of advertising are still rudimentary. It may be that the "liberal" (Paretian) foundations of welfare theory are unsuitable for such inquiry.

The theoretical and empirical studies published thus far offer no more than the most general policy guidelines. We know that intensity of advertising is associated with high concentration, high profits and prices, and increasing concentration. But this knowledge does not help us much in policy formulation. Even if the standard welfare analyses conclude that advertising is "wasteful" or "excessive," the answer may not be to restrict expenditures. Advertising is but one form of product differentiation, a highly fungible and multifaceted phenomenon. The recent U.S. experience with restrictions on cigarette advertising demonstrates the folly of a single-medium approach. Our inability to arrive at a consensus on how to identify the informative content of advertising is another impediment to policy formation. If the problem is one of too little information, public programs can supplement or supplant private ones; if there is too much information, counter-advertising activities may be a solution.

Perhaps, as Shaffer (*38*) has suggested, researchers have been asking the wrong questions about the economics of advertising. Even if advertising does convey useful information for rational decisionmaking, the more relevant question may be how advertising compares with other channels of dissemination. Similarly, if advertising and sales promotion do fuel market power, how can society deal with the income-redistribution effects of advertising? Given that advertising affects social beliefs and values, the more basic questions might be: Who should control advertising content, and are the present values projected by advertising consonant with the ideals of a democratic society?

References

(1) Bond, Ronald S., and others. *Staff Report on Effects of Restrictions on Advertising and Commercial Practice in the Professions: The Case of Optometry*. Washington, D.C.: Federal Trade Commission, 1980.

(2) Brown, Randall S. "Estimating Advantages to Large-Scale Advertising," *Review of Economics and Statistics*, Vol. 60, 1978, pp. 482-87.

(3) Butters, G. R. "Survey of Advertising and Market Power," *American Economic Review* (Proceedings), Vol. 66, 1976, pp. 392-97.

(4) Comanor, William S., and Thomas A. Wilson. *Advertising and Market Power*. Cambridge, Mass.: Harvard Univ. Press, 1974.

(5) _____. "The Effects of Advertising on Competition: A Survey," *Journal of Economic Literature*, Vol. 17, 1979, pp. 453-76.

(6) Connor John M. "*Food Product Proliferation: A Market Structure Analysis*." Working paper 41. Madison, Wis.: North Central Project 117, 1980.

(7) _____. *The U.S. Food and Tobacco Manufacturing Industries*. AER-451. U.S. Dept. Agr., Econ. Stat. Coop. Serv., 1980.

(8) Consumers Union. "Big Savings in Small Packages: No Names vs. Private Labels vs. Name Brands," *Consumer Reports*, Vol. 43, 1978, pp. 315-18.

(9) Dixit, Avinash, and Victor Norman. "Advertising and Welfare," *Bell Journal of Economics*, Spring 1978, pp. 1-17.

(10) Doyle, Peter, "Economic Aspects of Advertising: A Survey," *Economic Journal*, Vol. 8, 1968, pp. 570-602.

(11) Farris, Paul W., and Robert D. Buzzell. "Why Advertising and Promotional Costs Vary: Some Cross-Sectional Analyses," *Journal of Marketing*, Vol. 43, 1979, pp. 112-22.

(12) Federal Trade Commission. *Economic Report on the Influence of Market Structure on the Profit Performance of Food Manufacturing Companies*. Washington, D.C., 1969.

(13) Imel, Blake, and Peter Helmberger. "Estimation of Structure-Profit Relationships with Application to the Food Processing Sector," *American Economic Review*, Vol. 61, 1971, pp. 614-27.

(14) Kaldor, Nocholas. "The Economic Aspects of Advertising," *Review of Economic Studies*, Vol. 18, 1950, pp. 10-27.

(15) Kotowitz, Y., and F. Mathewson, "Informative Advertising and Welfare," *American Economic Review*, Vol. 69, 1979, pp. 284-94.

(16) _____. "Advertising, Consumer Information, and Product Quality," *Bell Journal of Economics*, Vol. 10, 1979, pp. 566-88.

(17) Marion, Bruce, and others. *The Food Retailing Industry: Market Structure, Profits, and Prices.* New York: Praeger, 1979.

(18) Mather, Loys. "Advertising and Mergers in the Food Manufacturing Industries." Working paper 36. Madison, Wis., North Central Project 117, 1979.

(19) Mottern, Nick. *Guidelines for Food Purchasing in the United States.* Report prepared for the U.S. Senate Select Committee on Nutrition and Human Needs. Washington, D.C., 1978.

(20) Mueller, Willard F., John Culbertson, and Brian Peckham. *Market Structure and Technological Performance in the Food Manufacturing Industry.* Final report to the National Science Foundation. Madison, Wis., 1979.

(21) Mueller, Willard F., and Richard Rogers. "The Role of Advertising in Changing Market Concentration," *Review of Economics and Statistics*, Vol. 62, 1980, pp. 89-96.

(22) Nelson, Phillip. "Advertising as Information," *Journal of Political Economy*, Vol. 82, 1974, pp. 729-54.

(23) Nerlove, Marc, and Frederick V. Waugh. "Advertising without Supply Control: Some Implications of a Study of the Advertising of Oranges," *Journal of Farm Economics*, Vol. 43, 1961, pp. 813-37.

(24) Neilsen Researcher. "Advertising and Sales Relationships," *Neilsen Researcher*, 1980. pp. 2-9.

(25) Pagoulatos, Emilio, and Robert Sorenson. "A Simultaneous Equation Analysis of Advertising, Concentration, and Profitability," *Southern Economic Journal*, Vol. 47, 1981 (forthcoming).

(26) Parker, Russell C., and John M. Connor. "Estimates of Consumer Loss due to Monopoly in the U.S. Food Manufacturing Industries," *American Journal of Agricultural Economics*, Vol. 61, 1979, pp. 626-39.

(27) Peles, Yoram. "Economies of Scale in Advertising Beer and Cigarettes," *Journal of Business*, Vol. 44, 1971, pp. 32-37.

(28) Porter, Michael E. *Interbrand Choice, Strategy, and Bilateral Market Power.* Cambridge, Mass.: Harvard Univ. Press, 1976.

(29) Preston, Ivan L. *The Great American Blow-up: Puffery in Advertising and Selling.* Madison: Univ. of Wisconsin Press, 1975.

(30) Reekie, W. Duncan. "Advertising and Market Share Mobility," *Scottish Journal of Political Economy*, Vol. 21, 1974, pp. 143-58.

(31) Resnik, Alan, and Bruce Stern. "An Analysis of Information Content in Television Advertising," *Journal of Marketing*, Vol. 41, 1977, pp. 50-53.

(32) Rogers, Richard T. "Advertising and Concentration Change in U.S. Food and Tobacco Product Classes, 1958-1972." Contributed paper at the annual meeting of the American Agricultural Economics Association, Urbana, Ill., 1980.

(33) _____. *The Cellar-Kefauver Act: 27 Years of Enforcement.* Appendix D. Report to the U.S. House of Representatives' Subcommittee on Monopoly. Washington, D.C., 1978.

(34) Scherer, F. M., and others. *The Economics of Multiplant Operation.* Cambridge, Mass.: Harvard Univ. Press, 1975.

(35) _____. *Industrial Market Structure and Economic Performance.* Chicago: Rand McNally, 1980.

(36) Schmalensee, Richard. "A Model of Advertising and Product Quality," *Journal of Political Economy*, Vol. 86, 1978, pp. 485-503.

(37) Scitovsky, Tibor. *The Joyless Economy.* Oxford, England: Oxford Univ. Press, 1976.

(38) Shaffer, James D. "Advertising in the Marketing Process," *Agricultural Market Analysis: Development, Performance, Process* (ed. Vernon L. Sorenson). East Lansing: Michigan State Univ. Business Studies, 1964.

(39) Smallwood, Dennis, and John Conlisk. "Product Quality in Markets where Consumers are Imperfectly Informed," *Quarterly Journal of Economics*, Vol. 93, 1979, pp. 1-24.

(40) Solomon, Richard L., and John D. Corbit. "An Opponent-Process Theory of Motivation," *American Economic Review*, Vol. 68, No. 6, 1978, pp. 12-24.

(41) Stigler, George J. "The Economics of Information," *Journal Political Economy*, Vol. 69, 1961, pp. 213-25.

(42) Stiglitz, J. E., "Equilibrium in Product Markets with Imperfect Information," *American Economic Review* (Proceedings), Vol. 69, 1979, pp. 339-45.

(43) Telser, Lester. "Advertising and Competition," *Journal of Political Economy*, 1964, pp. 537-62.

(44) Ward, Ronald, and Robert Behr. "Revisiting the Advertising Paradox," *American Journal of Agricultural Economics*, Vol. 62, 1980, pp. 113-17.

(45) Ward Ronald W., and Lester H. Myers, "Advertising Effectiveness and Coefficient of Variation Over Time," *Agricultural Economics Research*, Vol. 31, No. 1, 1979, pp. 1-11.

The Impact of the Voluntary Anti-Inflation Program on Retail Food Prices

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Abstract

The general purpose of the voluntary anti-inflation program was to limit price increases in markets where firms have discretionary price-setting power. Results suggest that the program was partly successful with respect to some domestic food markets. Retail prices for cereals and bakery products, sugar and sweets, other prepared foods, and processed fruits and vegetables all increased significantly less in 1978 and 1979 than they would have if there had been no anti-inflation program. Prices for other foods have not been affected, however.

Keywords

Anti-inflation program, Food prices, Econometric model

Introduction

In October 1978, the Carter Administration implemented a voluntary program of pay and price standards as part of a general anti-inflation effort. The basic goal was to limit pay and price increases in markets where firms had discretionary price-setting power, while giving fiscal and monetary policies "time to work." The program was designed to be voluntary and self-administered, with the Government reserving the right to withhold contracts from noncomplying firms. Large companies were requested to submit data to the Council on Wage and Price Stability (CWPS), which was assigned the task of implementing and maintaining the program.

Despite substantial evidence of active cooperation by most large corporations, the voluntary pay and price standards program has been criticized as ineffectual. On one side, economists like Trebing (*11*)[1] have argued that a voluntary program cannot work because it conflicts with the profit-maximizing objective of firms. On the other side, as Alperovitz and Faux (*1*) recently noted, many liberal economists urge the implementation of mandatory price controls because of enforcement difficulties and monitoring problems associated with the current program. CWPS (*4*) itself acknowledges the controversy concerning the effectiveness of the voluntary program, but it maintains that without the program the "underlying" inflation rate would have been 1.0 to 1.5 percentage points higher and the "overall" inflation rate about 0.50 to 0.75 percentage points higher since 1978.

The voluntary anti-inflation program does not cover markets for raw foodstuffs, but the food industry is subject to the general price standard applied to all industries.[2] As alternatives, however, a "percentage gross margin" standard is available to food wholesalers and retailers and a "gross margin" standard is available to food manufacturers; an optional "profit margin limitation" standard is available (with CWPS approval) to any firm which experiences unusual cost increases. CWPS has not publicly asserted that these standards have influenced retail food prices, but Hiemstra (*5*) has presented evidence that voluntary restraint has significantly limited food price inflation.

In this article, I determine what impact, if any, the voluntary anti-inflation program has had on retail food prices. To do this, I re-estimate the econometric model of the food industry developed by Lamm and Westcott (*9*), incorporating binary variables to measure program impacts.

The Program

During the first program year, the general price standard limited price increases by firms to a maximum of 9.5 percent, while it limited wage increases to 7 percent. The percentage-margin standard was made available to food wholesalers and retailers in lieu of the price standard because of the complexity of computing price changes for hundreds of different products. This standard was satisfied if a firm's adjusted net sales less the cost of goods sold as a percentage of net sales did not exceed its margin trend, or if its margin percentage in the program year did not exceed that of the base year. The gross margin standard, available for food manufacturers and

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[1] Italicized numbers in parentheses refer to items in the references at the end of this article.

[2] The program was designed partially to limit increases in most administered prices in the economy. Hence, competitive markets for agricultural products, other commodities, exports, and financial securities were excluded.

processors as an alternative to the price standard, was satisfied if the change in gross margins (adjusted net sales less the cost of goods sold) from the third quarter of 1978 to the third quarter of 1979 did not exceed 6.5 percent.

The profit margin limitation was available as a third alternative to both food manufacturers and processors and to wholesalers and retailers. This standard could be used by companies unable to satisfy the price standard because it was impossible to compute average price changes, because of uncontrollable cost increases, or because of undue hardship or inequity. The profit margin limitation was satisfied if the ratio of profit to net sales was no higher than the average profit margin for 2 of the 3 years in the base period (1975-77) and if program-year profit did not exceed base-year profit by more than 6.5 percent. CWPS approval for eligibility was required for this standard, however, and most firms in the food industry attempted to comply with the margin standards.

Retail food prices rose dramatically during the first year of the program, largely because of significant increases in the price of raw foodstuffs. This was especially true in the first half of 1979 when the Consumer Price Index (CPI) for food increased at a seasonally adjusted annual rate of 20.9 percent in the first quarter and 11.2 percent in the second quarter. During this period, the farm-to-retail price spread for the food industry increased much faster than marketing costs, resulting in higher food industry profits. This situation led to an August meeting between President Carter and representatives of the food industry at which the President urged restraint (see Lamm (*8*) for a review).

On September 28, 1979, the second year's program was announced by CWPS (*3*). Many of the basic rules established during the first year of the anti-inflation program were continued. However, a tripartite pay advisory committee was created, a price advisory committee was established, and most standards were extended to apply across 2 program years. Furthermore, firms were expected to limit their price increases in the second program year to no more than 8.5 percent (compared with 9.5 percent the first program year) and the profit-margin limitation was revised; growth in dollar profits was limited to 13.5 percent over both program years.

The basic policy toward violations was continued. CWPS first notified noncomplying firms privately to encourage voluntary adherence. If a firm failed to comply within a reasonable period, public pressure was utilized. Noncomplying firms in the food industry generally responded through voluntary price or margin reductions without public pressure, and there was substantial evidence of a persistent effort by firms to satisfy the program standards.

The Model

Using an econometric model to quantify any complex policy like that represented by the voluntary pay and price standards is difficult. The usual procedure in modeling such policies is to use a binary variable to represent the period over which the program is applied. This procedure makes it possible to approximate the program impacts if no other exogenous change occurs simultaneously, and it is the approach I follow here using the Lamm-Westcott model.

The Lamm-Westcott model (*9*) consists of a system of 20 linear equations, 15 of which link percentage changes in retail food prices, as represented by various components of the CPI for food, to changes in prices for raw farm products and other food marketing costs, such as labor, energy, and packaging materials. The model is essentially a single "stage of processing" model similar to that proposed by Popkin (*10*). It focuses on both the components of the farm-to-retail price spread and the changes in farm-level commodity prices with food marketing costs and raw foodstuffs prices considered as exogenous. The original version of the model was estimated with data from the second quarter of 1968 to the fourth quarter of 1977 and is currently used by the U.S. Department of Agriculture to forecast food prices.

Results

To perform the analysis, I added a binary variable representing the program implementation period for which data were available (the 5 quarters from fourth quarter 1978 to fourth quarter 1979) to each of the 15 food price equations in the Lamm-Westcott model. I then re-estimated each relation by ordinary least squares, using data from second quarter 1968 to fourth quarter 1979. This extended the time period covered in the original model, allowing for an explicit evaluation of the program effects.[3]

Table 1 presents the estimated structural coefficients for the binary program variables included in each food price equation. The reader is referred to the original Lamm-Westcott paper for the complete model specification. Each coefficient

[3]This procedure represents a disaggregated approach to program evaluation in which cross-effects are modeled explicitly. An alternative would be directly estimating an aggregate food CPI equation.

represents the percentage change in food prices attributable to the program. Table 1 also presents *t* statistics for tests of the null hypothesis that the binary program variable is zero, F statistics for tests of the null hypothesis that the addition of the binary variable adds significantly to the explanatory power of each equation, and statistics measuring the contribution of the program variable to the explanatory power of each equation.

The results indicate that the estimated coefficients for the voluntary anti-inflation program binary variables are marginally significant in only four cases: cereals and bakery products, sugar and sweets, other prepared foods, and processed fruits and vegetables. The critical *t* value at the 90-percent confidence level is slightly less than 1.70, while the critical F value at the 90 percent level is approximately 2.85, implying the same inference regardless of which test statistic is used.[4]

Indications are that the implementation of the voluntary anti-inflation program had a 0.74-percent negative impact per quarter on the change in the CPI for cereals and bakery products; a 1.86-percent negative impact per quarter on the change in the CPI for sugar and sweets; a 0.65-percent negative impact per quarter on the change in the CPI for other prepared foods, and a 1.50-percent negative impact per quarter on the change in the CPI for processed fruits and vegetables. These results seem plausible given the actual changes in the CPI's for these foods over the period studied.

Based on the reported test statistics, and since the original equations in the model passed a variety of validation tests, it seems that the parameters presented in table 1 are reasonable estimates of the effects of the voluntary anti-inflation program on retail prices for cereals and bakery products, sugar and sweets, other prepared foods, and processed fruits and vegetables. Consequently, we can conclude that the voluntary anti-inflation program had a restraining impact on prices for these foods. Similarly, the 11 price equations for which the program variable was found not to be statistically different from zero also seem to be reasonable representations, implying that the voluntary anti-inflation program had no impact on prices for 11 major food categories. These included: beef and veal, pork, other meats, poultry, fish and seafoods, eggs, dairy products, fats and oils, beverages, fresh fruits, and fresh vegetables.

Using the relationship between changes in CPI components and changes in the CPI aggregates and the relationship between re-estimated price equations for cereals and bakery products, sugar and sweets, other prepared foods, and processed fruits and vegetables, I estimate that the implementation of the voluntary anti-inflation program had a negative impact of approximately 0.3 percent per quarter on changes

[4]Note that the program variable for the cereals and bakery products equation is significant at the 85-percent level on the basis of the *t* test and at the 82-percent level on the basis of the F test. The decision to accept this low level of confidence is arbitrary.

Table 1—Estimated coefficients for binary variables representing the impact of the voluntary anti-inflation program on food prices

Consumer Price Index	Estimated coefficient	Statistic		Contribution to R^2
		t	F	
Beef and veal	0.61	0.50	0.28	0.10
Pork	1.09	1.08	.11	.23
Other meats	.37	.93	.31	.09
Poultry	-.75	-.65	.43	.11
Fish	-.30	-.59	.04	.43
Eggs	.13	.08	.01	.00
Dairy products	-.05	-.12	.02	.01
Cereals and bakery products	-.74	-1.44	2.08	.72
Fats and oils	-.55	-.63	.43	.14
Sugar and sweets	-1.86	-2.12	4.55	.98
Other prepared foods	-.65	-1.93	3.83	1.14
Nonalcoholic beverages	-1.45	-1.27	1.60	.99
Fresh fruits	1.36	1.07	1.02	.22
Fresh vegetables	.08	.03	0	.01
Processed fruits and vegetables	-1.50	-1.91	3.65	2.86

Because food processors and distributors are covered by the program, and most have used margin standards as a guide for limiting prices, it would seem that the greatest price-limiting impacts of the voluntary anti-inflation program would be on those foods with relatively large farm-to-retail margins. . . .

in the CPI for food consumed at home. Because the CPI for food consumed at home rose an average of 2.0 percent each quarter from fourth quarter 1978 through fourth quarter 1979, we may conclude that the voluntary anti-inflation program has had a moderate restraining effect on food prices.

Implications

The voluntary anti-inflation program limits price increases in markets where firms have discretionary pricing power, but does not cover markets for raw foodstuffs which are basically competitive. Because food processors and distributors are covered by the program, and most have used margin standards as a guide for limiting prices, it would seem that the greatest price-limiting impacts of the voluntary anti-inflation program would be on those foods with relatively large farm-to-retail margins; more of the final price of these foods is subject to control under voluntary compliance.

Cereals and bakery products, sugar and sweets, "other prepared foods," and processed fruits and vegetables are foods with relatively large farm-to-retail margins. Manufacturing and retailing jointly account for about 85 percent of the total value of cereals and bakery products; sugar processors and distributors account for almost 55 percent of the total value of sugar; and manufacturers and distributors of processed fruits and vegetables account for almost 80 percent of the total value of processed fruits and vegetables (table 2). For this reason, one would expect the voluntary anti-inflation program to have affected retail prices for these products substantially, given discretionary pricing power. That is precisely what the estimates suggest.

Table 2—Approximate value-added by food processors and distributors as a percentage of the cost of food to consumers

Food group	1977	1978	1979
	Percent		
Meat products	45	42	43
Dairy products	50	49	48
Poultry	45	43	46
Eggs	35	33	32
Cereals and bakery products	87	86	85
Fresh fruits	71	68	71
Fresh vegetables	67	68	70
Processed fruits and vegetables	82	81	81
Fats and oils	64	66	66
Sugar and sweets	61	55	55
All domestic foods	63	61	61

In contrast, food processing and distributing account for only one-third to one-half of the total value of meats and meat products, dairy products, poultry, and eggs. Therefore, the final price of these products would be less subject to control under voluntary compliance and the program might not have as much impact on retail prices. Again, the estimation results support this conclusion.

Thus, the voluntary anti-inflation program has had the greatest impact on those food prices which are subject to the most potential control, and it has had no identifiable impact on the retail prices of foods whose margins represent a smaller percentage of total food value.

In addition, substantial price-limiting gains would be expected for food industries having the most price-setting power. Firms in these concentrated industries would not be harmed substantially by limiting price increases in the short run because they presumably already extract some excess profit as a result of their market power. They could "afford" to comply, because public exposure from noncompliance might adversely affect their market share. In contrast, the incentive to avoid compliance is greatest in those industries which are fairly competitive and not highly concentrated; price restraints might induce less than normal returns, causing some firms to leave the industry.

The results presented here support these contentions. Most industries which manufacture foods classified in the CPI categories for cereal and bakery products, sugar and sweets, and other prepared foods are among the most highly concentrated in the U.S. food manufacturing sector (table 3). Manufacturing industries producing processed fruits and vegetables are not highly concentrated nationally but are moderately concentrated after adjustment for local market share (see Connor (2)). In contrast, food industries like meatpacking, poultry processing, fluid milk processing and other food manufacturing industries are less concentrated.[5] Hence, the voluntary anti-inflation program has had a significant impact on more concentrated industries and no impact on less concentrated ones. This implies that the program has tended to affect substantially price increases in food industries with the most discretionary pricing power.

[5]Food manufacturing industry classifications do not match exactly the product classifications used in the CPI, although an approximation can be obtained. For example, the creamery butter, cheese, condensed and evaporated milk, ice cream and frozen dessert, and fluid milk industries produce most of the products included in the dairy products CPI.

Table 3—Concentration ratios for selected food industries, 1972

Industry[1]	Concentration ratios		
	4 firms	8 firms	20 firms
	Percent		
Meatpacking plants (2011)	22	37	51
Sausages and other prepared meats (2013)	19	26	38
Poultry dressing plants (2016)	17	26	42
Poultry and egg processing (2017)	23	36	65
Creamery butter (2021)	45	58	78
Cheese (2022)	42	53	65
Condensed and evaporated milk (2033)	39	58	76
Ice cream and frozen dessert (2024)	29	40	58
Fluid milk (2026)	18	26	42
Canned specialties (2032)	67	81	94
Canned fruits and vegetables (2033)	20	31	53
Dehydrated fruits, vegetable soups (2034)	33	51	76
Frozen fruits and vegetables (2037)	33	46	62
Flour and other grain mill products (2041)	33	53	75
Cereal breakfast foods (2043)	90	98	99
Rice milling (2044)	43	68	92
Blended and prepared flour (2045)	68	81	92
Bread, cake, and related products (2051)	29	39	50
Cookies and crackers (2052)	59	69	83
Raw cane sugar (2061)	44	62	84
Cane sugar refining (2062)	59	85	99
Confectionery products (2065)	32	42	59
Chocolate and cocoa products (2066)	74	88	99
Chewing gum (2067)	87	98	100
Shortening and cooking oils (2079)	44	70	93
Bottled and canned soft drinks (2086)	14	21	32
Fresh and frozen fish (2092)	20	32	53
Roasted coffee (2095)	65	79	92
Macaroni and spaghetti (2098)	38	53	76

[1]Standard Industrial Classification (SIC) numbers are given in parentheses.
Source: U.S. Department of Commerce, *1972 Census of Manufactures.*

Conclusion

The basic finding of this study is that the voluntary anti-inflation program restrained increases in retail food prices by approximately 0.3 percent over each of the five quarters from fourth quarter 1978 through fourth quarter 1979. This negative impact was greatest on retail prices for cereals and bakery products, sugar and sweets, other prepared foods, and processed fruits and vegetables. This might have been expected, however, as the potential gains from control would be substantial for these food groups; farm-to-retail margins have been the largest and concentration has been the highest in these industries.

These findings show how the voluntary anti-inflation program has affected prices in the food industry and also that the program has had an impact. Proponents of the program may find these results encouraging. However, the model estimates are less than perfect statistically and the binary program variable is less than satisfactory. Nonetheless, the findings partly validate the contentions of those who claim that the anti-inflation program did restrain increases in retail food prices.

References

(1) Alperovitz, G., and J. Faux. "Controls and the Basic Necessities," *Challenge*, May-June 1980, pp. 21-29.

(2) Connor, J. M. *The U.S. Food and Tobacco Manufacturing Industries: Market Structure, Structural Change, and Economic Performance.* AER-451. U.S. Dept. of Agr., Econ. Stat. Coop. Serv., Mar. 1980.

(3) Council on Wage and Price Stability. *Anti-Inflationary Pay and Price Standards.* Washington, D.C., Sept. 28, 1979.

(4) _____. *The Pay/Price Standards Program: Evaluation and Third-Year Issues.* Washington, D.C., July 8, 1980.

The basic finding of this study is that the voluntary anti-inflation program restrained increases in retail food prices by approximately 0.3 percent over each of the five quarters from fourth quarter 1978 through fourth quarter 1979.

(5) Hiemstra, S. "Impacts of Pay and Price Standards on the Food Industry." Paper presented at the annual meeting of the Southern Economic Association, Atlanta, Ga., Nov. 8, 1979.

(6) Lamm, R. M. "The USDA Food Price Monitoring Program," *National Food Review*, Fall 1979, p. 9.

(7) _____. "Wage and Price Standards Review," *National Food Review*," Winter 1980, pp. 37-38.

(8) _____. "The ESCS Food Data System and Public Policy Implementation," *Review of Public Data Use*, Vol. 8, 1980, pp. 265-70.

(9) Lamm, R. M., and P. Westcott. "The Impact of Changing Input Costs on Food Prices," *American Journal of Agricultural Economics*, Vol. 63, 1981 (forthcoming).

(10) Popkin, J. "Consumer and Wholesale Prices in a Model of Price Behavior by State of Processing," *Review of Economics and Statistics*, Vol. 56, 1974, pp. 486-501.

(11) Trebing, M. "The Economic Consequences of Wage-Price Guidelines," *Review*, Federal Reserve Bank of St. Louis, Vol. 60, 1978, pp. 2-7.

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Charles F. Sarle
Vol. 5, No. 2, April 1953, pp. 25-26

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